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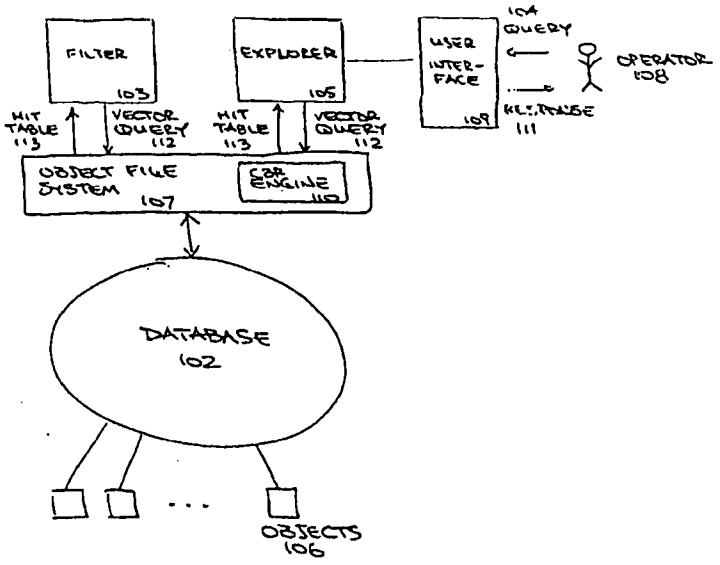

(57) Abstract

A system for case-based organizing and querying of a database (102). The database (102) may comprise a set of objects (106), such as text documents. The database (102) may be organized by examining each object (106) and associating that object (106) with a set of property values, such as keywords. A document may be associated with those words which appear more frequently in the document than in the database (102) at large, or which appear in the early text of the document, or which appear in the title. The system may be responsive to a query (104) by associating the query with a similar set of property values and performing case-based matching on the objects (106) of the database (102) for similar objects (106). The query (104) may be natural-language text and may be associated with keywords. The system may present matched objects in response to the query (104), may respond to iterative refinement of the query and may order matched objects by quality of match. The system may also respond to the result of organizing matched objects for presentation with suggestions for iterative refinement of the query (104).

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CASE-BASED ORGANIZING AND QUERYING OF A DATABASE

1. Field of the Invention

This invention relates to case-based organizing and querying of a database.

2. Description of Related Art

As storage capability grows for computing devices, many databases have become larger, and large databases have become more common. One problem which has become apparent in the art is the difficulty of retrieving information from large databases when the location of that desired information is not already known. For example, a search for information in a large library may be hampered by the size of the library, because of the large number of items which must be examined. This can be exacerbated if the information searched for is not well-described by the searcher, if the searcher is unfamiliar with that subject matter, or if the information searched for is not well indexed.

Large databases of objects may sometimes be generated without the original intent to organize them into a database. For example, newspaper articles may generally be written without the consideration that they may be collected into a single database for later search. When they eventually are collected into a database, the effort required to organize those objects into a database for information retrieval can be formidable. It

would be advantageous to provide a system in which a large amount of information may be collected into a database without having to expend a comparable amount of effort on organization and indexing, e.g., where such organization and indexing can be done by an automated process.

Prior art methods of retrieving information generally require preparation of a query, in which objects to be searched for are described in some formal manner. This imposes additional effort on the searcher, and generally also requires that the searcher be familiar with the subject matter to be searched, with the organization and indexing of the database, and with a formal query language. Accordingly, it would be advantageous for the searcher to be able to describe the query in a natural and relatively informal or unstructured manner, such as a description in a natural language.

Work with case-based systems has shown that incremental refinement of problem descriptions can be valuable in improving a automated system's recall (ability to retrieve objects which are related to the query) and precision (ability to rule out objects which are not related to the query). It would be advantageous to be able to incrementally refine the query after a response. But when the query itself is unstructured, the original response may provide so much information that valuable material is lost in the size of the response. Accordingly, it would be advantageous to provide suggestions for incremental refinement. In one aspect of the invention, the response may be organized by quality of match.

In another aspect, the response may be organized into clusters of related objects.

SUMMARY OF THE INVENTION

The invention provides a system for case-based organizing and querying of a database. The database may comprise a set of objects, such as a set of documents including text. In a preferred embodiment, the database may be organized by examining each object and associating that object with a set of property values, such as (in the case of text documents) a set of keywords or other indicators of content. For example, a document may be associated with those words which appear more frequently in the document than in the database at large, or which appear in early text of the document, or which appear in a title. The system may be responsive to a query by associating the query with a similar set of property values and performing case-based matching or other fuzzy associative matching on the objects of the database for objects which are similar. In a preferred embodiment, the query may be natural-language text and may be associated with keywords or other indicators of its content.

In a preferred embodiment, the system may present matched objects in response to the query, may respond to iterative refinement of the query (in similar manner to iterative case-based methods shown in those co-pending applications which have been incorporated by reference), and may order matched objects by quality of match. The system may also examine the

collection of matched objects and organize them for presentation; for example, the system may group matched objects into clusters of objects which have similar properties, which relate to similar content, or which have similar likelihood to be of relevance to the query or of interest to an operator posing the query. The system may respond to the result of organizing matched objects for presentation with suggestions for iterative refinement of the query.

The system may therefore be capable of producing improved recall and precision over prior art techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of a database explorer and filter system.

Figure 2 shows a data flow diagram of a method of filtering documents.

Figure 3 shows a data flow diagram of a method of processing queries.

Figure 4 shows a data flow diagram of a method of processing hit tables.

Figure 5 shows a process flow diagram of a method of clustering hit tables.

Figure 6 shows an example explorer user interface screen as viewed by an operator.

Figure 7 shows a second example explorer user interface screen, as viewed by an operator, in which clusters are displayed.

Figure 8 shows an example explorer user interface screen, as viewed by an operator, in which settings may be set by the operator.

Appendix A shows a table of parts of speech and a set of lexical rules for the English language, which may be used for the tag-and-segment-text process or the tag-and-segment-text process in a preferred embodiment.

Appendix B shows an output of a test run of an example filter when applied to a portion of an example multimedia encyclopedia used as a database, available as "Microsoft Encarta" from Microsoft Corporation of Redmond, Washington.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of this invention may be used together with inventions which are disclosed in a copending application titled "AUTONOMOUS LEARNING AND REASONING AGENT", application Serial No. 07/ 869,926, filed April 15, 1992 in the name of

Bradley P. Allen, hereby incorporated by reference as if fully set forth herein.

In a preferred embodiment, the invention may operate in conjunction with a computing system, including a processor and a memory, generally configured as is well known in the art; the memory may include primary memory for stored programs and for data and secondary memory for extensive storage of large numbers of objects. Preferably, the memory may comprise a sizable database of objects, as is well known in the art of databases, and such objects may comprise various types of computing and data-storage structures. However, no particular structure is required for the database itself; the database may be a relational database, an unstructured collection of objects, or some other database format.

Although the invention is disclosed herein primarily with respect to textual objects, it would be clear to those of ordinary skill in the art, after perusal of the application, that extension of the concepts disclosed to other types of objects is within the scope and spirit of the invention, and would not require undue experimentation. Such other types of objects may include source code, object code, binary values, numeric values, text or other symbolic values, representations of sound and/or picture signals or other signals, multimedia, data structures for rule-based or case-based systems, artificial neural networks, linked data structures such as linked lists, mathematical structures such as equations, polynomials, matrices or tensors,

and other data types known in at least one of the many fields of computing. Although when the invention is applied to textual objects, appearance of a text string in an object is considered pertinent, when the invention is applied to other types of objects, other measures of closeness or pertinence, such as numerical closeness, would be workable, and are within the scope and spirit of the invention.

FILTER AND EXPLORER SYSTEM

Figure 1 shows a block diagram of a database explorer and filter system.

In a preferred embodiment, a system 101 for case-based organizing and querying of a database 102 may comprise a filter 103, for organizing the database 102 so as to be responsive to a query 104, an explorer 105, for selecting a set of objects 106 in the database 102 which are responsive to that query 104, and an object file system 107, for accessing the database 102. In a preferred embodiment, the database 102 may generally be of a type which is known in the art, such as a collection of text objects supported by Cairo Milestone 4 running under the Windows NT system version 297, available from Microsoft Corporation of Redmond, Washington, and may be accessed in conjunction with the object file system 107 of that product.

The filter 103 may operate at an initialization time, such as when the processor is first started or before the first

query 104 is presented to the explorer 105. The filter 103 may also operate in an incremental mode, e.g., by updating its organization of the database 102 periodically, such as upon the passage of a fixed period of time, when a fixed number of objects 106 are changed or added to the database 102, when the operation of the explorer 105 is degraded below some predetermined level, when triggered by an operator 108 in conjunction with a user interface 109 (e.g., when a query is presented, by a specific command to do so, or as a side effect of another operation), or otherwise as determined by the database 102 or an external manager.

The filter 103 may examine each of the objects 106 (or some predetermined subset of objects 106) in the database 102 and associate each object 106 it examines (or some predetermined subset of those objects 106) with a set of properties. For a textual database 102 as primarily described herein, those properties may be keywords or phrases which are found in the object 106, but may also comprise other property values, such as the language the text is written in, the length of the text, or the reading level or other measure associated with the text (including measures of complexity, detail, redundancy, writing style, "fog", or other known measures of text, e.g., known in the art of grammar checking and correction).

The objects 106 with their properties may be treated as a set of cases to be matched by a CBR engine 110 (operating with the object file system 107) with a test case generated from the

query 104. Each case may generally comprise an object 106 plus the properties that object 106 was associated with, e.g., key words and phrases found in that object. In a preferred embodiment, these properties may include a lexicon of words and noun phrases found in the object 106, including at least some of these words labelled as a set of "header words" or "relevant words".

The explorer 105 may generally operate at a question time, such as when one or more queries 104 is presented to the explorer 105. In a preferred embodiment, the explorer 105 may be invoked by the operator 108 in conjunction with the user interface 109, which user interface 109 may allow the operator to trigger operation of the explorer 105 and to present one or more queries 104 to the explorer 105. In a preferred embodiment, the user interface 109 may be one such as the user interface presented by the Windows NT system referred to herein. In a preferred embodiment, the operator 108 may be a human being, but those of ordinary skill with recognize, after perusal of the application, that the operator 108 may comprise a network connection, an external management program, or an AI program.

In a preferred embodiment, the explorer 105 may generate a response 111 including a set of matching cases (i.e., objects 106 with their properties), which may be presented to the operator 108 by means of the user interface 109, such as the user interface presented by the Windows NT system referred to herein, augmented by features described herein.

The filter 103 and the explorer 105 may operate in conjunction with the object file system 107 (and in particular the CBR engine 110 thereof), which may respond to a set of properties formed into a vector query 112 directed at the database 102, and may return a hit table 113 of those objects 106 in the database 102 which have the indicated properties. In a preferred embodiment, the CBR engine 110 may use case-based matching and other techniques such as those shown in those co-pending applications which have been incorporated by reference.

FILTERING DOCUMENTS

Figure 2 shows a data flow diagram of a method of filtering documents.

In a preferred embodiment, a document 201 (an object 106 which comprises text, such as a pure text document or a text document formatted for a word-processing program) may be input to the filter 103 for examination. The filter 103 may process the text by a tag-and-segment-text process 202, which may lexically analyze the document 201, e.g., by means of a known lexical analysis technique.

The tag-and-segment-text process 202 may extract a set of single terms 203 and generate a set of header words 204 found in the document 201. The header words 204 may comprise those words which occur in an initial part of the object 106, or in a title, subject line, topical paragraph, or abstract. In a

preferred embodiment, the header words 204 may comprise the first three things mentioned in the document 201.

The tag-and-segment-text process 202 may also tag words in the document 201 with their parts of speech and parse them into a set of sentences 205. The sentences 205 may be input to an extract-noun-phrases process 206, which may further lexically analyze the document 201, e.g., by means of a known lexical analysis technique, to extract a set of noun phrases 207 and generate a lexicon 208 thereof. In a preferred embodiment, the tag-and-segment-text process 202 may use a grammar of the English language, but other natural languages, and even formal specification languages such as programming languages, would also be suitable.

The tag-and-segment-text process 202 may also recognize and generate a set of proper nouns 209. In a preferred embodiment, the set of proper nouns 209 may be determined by known rules, e.g., that proper nouns generally comprise strings of words each starting with an upper-case letter, or by reference to a dictionary of known proper names. The set of proper nouns 209 may be input, along with at least some of the single terms 203, to a determine-relevant-words process 210, which may extract a set of relevant words 211.

The set of relevant words 211 may be determined with reference to the frequency of those words in the object 106 (with respect to the entire text found in the object 106) and with

reference to the frequency of those words in the database 102, with respect to the text corpus of the database 102. In a preferred embodiment, the ratio for each word (frequency in the object 106) divided by (frequency in the database 102) may be computed, and the set of relevant words 211 may comprise those words whose relative frequency exceeds a threshold, e.g., a predetermined threshold such as a 1:1 ratio. However, it would be clear to those of ordinary skill, after perusal of this application, that other measures (e.g., statistical measures) relating to frequency could be used to determine relevant words, such as clustering of relevant words in paragraphs, correlation with other relevant words, or relative frequency of word pairs or n-tuples, and that such other measures are within the scope and spirit of the invention.

The filter 103 is described herein for a specific set of properties of the text which may be extracted. However, it would be clear to those of ordinary skill, after perusal of this application, that extraction of other properties could be readily accomplished, and is within the scope and spirit of the invention. Such other properties could include the language the text is written in (or for English-language text, the number of foreign words used), the length of the text, or the reading level or other measure associated with the text (including measures of complexity, detail, redundancy, writing style, "fog", or other known measures of text, e.g., known in the art of grammar checking and correction).

In a preferred embodiment, the extract-noun-phrases process 206 and the determine-relevant-words process 211 may proceed in parallel, e.g., by execution on multiple processors or by multiple tasks or threads in a multitasking or multithreaded environment.

The filter 103 may mark each object 106 with the properties it determines (or alternatively may create a separate object 106 relating each documentary object 106 to its properties), so that the object 106 and its properties may be treated as a case in a case-base. In a preferred embodiment, the set of cases may be matched to a test case by a CBR engine 110, using techniques like those described in copending applications (1) Serial No. 07/ 664,561, filed March 4, 1991 in the name of inventors **Bradley P. Allen** and **S. Daniel Lee**, titled "CASE-BASED REASONING SYSTEM"; (2) Serial No. 07/ 869,935, filed April 15, 1992 in the name of inventor **Bradley P. Allen**, titled "MACHINE LEARNING WITH A RELATIONAL DATABASE"; and (3) Serial No. 07/ 869,926, filed April 15, 1992 in the name of **Bradley P. Allen**, titled "AUTONOMOUS LEARNING AND REASONING AGENT"; each of which is hereby incorporated by reference as if fully set forth herein, or other case-based reasoning techniques which may be known in the art.

PROCESSING QUERIES

Figure 3 shows a data flow diagram of a method of processing queries.

In a preferred embodiment, the query 104, entered in free text by the operator 108, may be input to the explorer 105 for examination. The explorer 105 may process the text by a tag-and-segment-text process 301, which may lexically analyze the document 201, e.g., by means of a known lexical analysis technique, similarly to the tag-and-segment-text process 202 of the filter 103.

The tag-and-segment-text process 301 may extract a set of single terms 302, similarly to the tag-and-segment-text process 202 and the set of single terms 203 of the filter 103.

The tag-and-segment-text process 301 may also tag words in the document 201 with their parts of speech and parse them into a set of sentences 303, similarly to the tag-and-segment-text process 202 and the sentences 205 of the filter 103. The sentences 303 may be input to an extract-noun-phrases process 304, which may further lexically analyze the document 201, e.g., by means of a known lexical analysis technique, to extract a set of noun phrases 305, similarly to the extract-noun-phrases process 206 and the noun phrases 207 of the filter 103.

The tag-and-segment-text process 301 may also recognize and generate a set of proper nouns 306, similarly to the tag-and-segment-text process 202 and the proper nouns 209 of the filter 103.

The noun phrases 305, single terms 302, and proper nouns 306, a rank threshold 307, and a set of selected subtopics 308 (subtopics selected by the operator 108 to refine the query 104) may be input to a generate-query process 309, which may generate a set of query terms 310 and a query parse tree 311.

In a preferred embodiment, the tag-and-segment-text process 301, the extract-noun-phrases process 304, and the generate-query process 309 may proceed as asynchronously as possible, e.g., by execution on multiple processors or by multiple tasks or threads in a multitasking or multithreaded environment.

The query terms 310 and the query parse tree 311 may be input to the CBR engine 110 in the object file system 107, and may perform case-based matching or other fuzzy associative matching on the objects 106 in the database 102 for objects which are similar to the query 104, as described by the query terms 310 and the query parse tree 311, and which have a match quality at least as good as the rank threshold 307. (As noted with regard to the user interface 109, the selected subtopics 308 are added to the text of the query 104.) The object file system 107 may generate the hit table 113 of matched objects 106.

PROCESSING HIT TABLES

Figure 4 shows a data flow diagram of a method of processing hit tables.

The hit table 113 and the relevant words 211 may be input to a cluster hits process 401, which (if clustering is enabled) collects the matched objects 106 into clusters, and may output a set of clusters 402 in response. Each cluster 402 may comprise a set of objects 106, selected for collective closeness with regard to all objects 106 in the hit table 113. The cluster hits process 401 is further described with regard to figure 5.

The hit table 113, the relevant words 211, and the lexicon 208 may be input to a first generate-topics (from relevant words) process 403, while the lexicon 208 and the query terms 310 may be input to a second generate-topics (from query words) process 403. Together the two generate-topics processes 403 may output a set of topics 404 and subtopics 405.

In a preferred embodiment, the generate-topics process 403 may examine the lexicon 208 of noun phrases 207 with a rule-based inference engine (not shown). (One such inference engine is the ART-IM system, available from Inference Corporation in El Segundo, California.) The inference engine may detect particular patterns in the noun phrases 207 which indicate semantic relations between the words in those noun phrases 207. For example, the noun phrase

"kangaroos, wallabies, and other marsupials"

would be detected and would generate the relations

kangaroo IS-A marsupial

wallaby IS-A marsupial

The generate-topics process 403 may thus construct a phrase lattice, showing each noun phrase 207 as being inclusive of (above), included in (below), or incommensurate with (neither above nor below) each other noun phrase 207.

The generate-topics (from relevant words) process 403 may restrict the phrase lattice to those noun phrases 207 which include relevant words 211 of the objects 106 in the hit table 113. In a preferred embodiment, the second generate-topics (from query words) process 403 may operate in similar manner as the first generate-topics (from relevant words) process 403 and may restrict the phrase lattice to those noun phrases 305 which include relevant words 211 of the query.

Figure 5 shows a process flow diagram of a method of clustering hit tables.

The cluster hits process 401 may operate by means of a genetic algorithm, in which an initial configuration and a set of genetic operators are specified, and the set of solutions is formed by simulation of random "evolution" of a population of possible solutions, using the method of steady-state reproduction without duplicates. Genetic algorithms are well known in the art, and are described in further detail in "Foundations of Genetic Algorithms", ed. Gregory J.E. Rawlins (Morgan Kaufmann

Publishers: San Mateo, California 1991). It would be clear to those of ordinary skill in the art that the parameters of the genetic algorithm, and even the type of genetic algorithm performed could be varied substantially and still remain within the scope and spirit of the invention.

In a cluster-count step 501, a number of clusters 402 is selected. The number of clusters 402 may vary from a known minimum to a known maximum, settable by the operator 108. The genetic algorithm of the following steps is repeated for each permissible number of clusters 402, and the best solution adopted.

In an initiate-clusters step 502, a set of possible clusters 402 is selected; this is a single "gene". A random population of genes is selected. Each cluster 402 is represented by the centroid of the objects 106 which would comprise that cluster 402. Thus, when a solution of clusters 402 is selected, each object 106 is assigned to the cluster 402 which it best matches.

After the initiate-clusters step 502, the genetic algorithm of the following steps is repeated for a known period of time, settable by the operator 108. When that time expires, the best available solution (i.e., the gene with the best quality) is selected as the solution and specifies the set of clusters 402. Each object 106 is assigned to the cluster 402 to which it is the closest.

In an evaluation step 503, all genes in the population are evaluated for quality, and the gene with the least quality is removed. In a preferred embodiment, the statistical measure "category utility" is computed; i.e., the utility of each cluster 402 in distinguishing between an object 106 in one cluster 402 from an object in another cluster 402. Thus, if the centroid of a cluster 402 has high quality of match for several objects 106, those objects are reasonably clustered together.

Although in a preferred embodiment, matching for clusters 402 is performed using relevant words 211, it would be clear to those of ordinary skill, after perusal of this application, that other properties of the objects 106 could be used as well, such as the read/write date of the object 106, and that doing so would be within the scope and spirit of the invention.

In a genetic-operator step 504, one of three operators is selected and employed to create a new gene: (1) Mutation-1. The new gene is randomly created. (2) Mutation-2. An existing gene is copied, except that one of its clusters 402 is mutated by replacing it with a randomly created cluster 402. (3) Crossover. Two genes have their n-tuples of clusters 402 paired off and one cluster 402 is selected at random from each pair to form the new gene. Alternatively, a new gene is created by selecting N clusters 402 at random from the 2N clusters 402 specified by the two old genes.

USER INTERFACE

Figure 6 shows an example explorer user interface screen as viewed by an operator. While the invention is described primarily with regard to a specific user interface, it would be clear to those of ordinary skill in the art that another user interface of equal or greater flexibility would be suitable, and would be within the scope and spirit of the invention.

In a preferred embodiment, the user interface 109 may be combined with a user interface for a generalized file system exploration program, such as in the Windows NT system referred to herein. The user interface 109 may comprise a query window 601 in which the operator may enter the query 104 in free text, and a results window 602 in which the system 101 may display a set of matched objects 106 found in response to the query 104.

In a preferred embodiment, the operator 108 may enter the query 104 in the query window 601. The query 104 is input to the explorer 105, which processes it as described herein, and generates the vector query 112. The vector query 112 is input to the object file system 107, and generates the hit table 113 of matched objects 106. The hit table 113 is input to the user interface 109, which displays the matched objects 106. The operator may select a displayed matched object 106 to view its contents.

In a preferred embodiment, the user interface 109, the explorer 105, and the object file system 107, may operate as asynchronously as possible. Accordingly, the object file system 107 may search the database 102 for matched objects 106 independently, once it has sufficient information from the explorer 105; the user interface 109 may display matched objects 106 from the hit table 113 as they are generated by the object file system 107.

In the example, the operator 108 has entered the query 104 "who invented the light bulb?" in a content field 603 of the query window 601, and the system 101 has responded with a set of matched objects 106 in the results window 602. The matched objects are displayed one per line, in columns labelled "rank", "query", "header", and "relevant words".

In the example, a rank field 604 displays the quality of match for each displayed matched object 106. In a preferred embodiment, the system 101 may order the matched objects 106 by rank. This may occur as the normal procedure, or at the request of the operator 108, e.g., by means of a "sort" command 605 in the query window 601. In a preferred embodiment, the rank field 604 may also be color-coded by value.

In the example, a query field 606 displays the relevant words of the query which are most related to the displayed matched object 106.

In the example, a header field 607 displays the header words 204 of the displayed matched object 106.

In the example, a relevant words field 608 displays the most common relevant words 211 of the displayed matched object 106.

In the example, a topics field 609 of the query window 601 displays suggested topics for refinement of the query 104 which the system 101 has identified. In a preferred embodiment, the operator 108 may select a topic in the topics field 609, and the system will display a subtopics window 610 (overlaid on the query window 601 and the results window 602) showing the subtopics which the system 101 has identified for that topic.

QUERY REFINEMENT

The operator 108 may refine the query 104 in response to the matched objects 106, and the explorer 105 may attempt to match objects 106 using the query 104 as refined. This may occur at the request of the operator 108, e.g., by means of a "refresh" command 611 in the query window 601.

In a preferred embodiment, the operator 108 may select one or more subtopics 405 to refine the query 104. To do so, the operator 108 may identify (e.g., by pointing to with a pointing device such as a mouse) one or more subtopics 405 in the subtopics window 610. The selected subtopics 308 may be "added"

to the query 104 and the explorer 105 may attempt to match objects 106 using the query 104 as refined.

In a preferred embodiment, the operator 108 may also select one or more relevant words 211 to refine the query 104. To do so, the operator 108 may identify (e.g. by pointing to) the relevant words field 608 for a particular matched object 106 and "drag" that relevant words field 608 to the content field 603; the system 101 will display a relevance feedback window 612 (overlaid on the query window 601 and the results window 602) showing the relevant words 211 for that matched object 106.

In a preferred embodiment, the operator 108 may select one or more relevant words 211 to refine the query 104. To do so, the operator 108 may identify (e.g., by pointing to) one or more relevant words 211 in the relevance feedback window 612. The selected relevant words 211 may be "added" to the query 104 and the explorer 105 may attempt to match objects 106 using the query 104 as refined.

The query 104 as refined (like the original query 104) is presented as a vector query 104 to the CBR engine 110. When selected subtopics 308 or relevant words 211 are "added" to the query, they are properties which the CBR engine 110 must match to objects 106, as described for methods of iterative refinement of case-based matching shown in those co-pending applications which have been incorporated by reference. (Thus, the CBR engine 110 must match to objects 106 as if the operator 108 had answered a

query refining question in a case-based system.) A query 104 as refined may be further refined, allowing the operator to iteratively refine the query 104 until desired objects 106 are located.

VIEWING CLUSTERS

Figure 7 shows a second example explorer user interface screen, as viewed by an operator, in which clusters are displayed.

The operator 108 may select a "cluster" command (figure 6) or "uncluster" (figure 7) command 701 in the query window 601, and the system 101 will display a set of clusters 402, each a set of related matched objects 106, in place of displaying matched objects 106 themselves. In the example, the operator has selected the "cluster" command 701 for the same query 104 as in the example of figure 6.

In the example, an expand field 702 displays whether the cluster 402 can be expanded (shown by a "+" symbol) to display individual matched objects 106, or can be collapsed (shown by a "-" symbol) to display a single identifier for the cluster 402.

In the example, the rank field 703 displays the best rank for all matched objects 106 in the cluster 402. In a preferred embodiment, the system 101 may order the clusters 402

by this rank field 703. This may occur as the normal procedure, or at the request of the operator 108, e.g., by means of the "sort" command 605 in the query window 601. In a preferred embodiment, this rank field 703 may also be color-coded by value.

In the example, the relevant words field 608 displays the most common relevant words 211 in the cluster 402.

Other fields and windows remain similar to the example of figure 6.

The operator 108 may also choose to cluster all objects 106 in a specific set, e.g., a specific directory in the object file system 107. In a preferred embodiment, the operator 108 may restrict the scope of the explorer 105 to a specific directory and issue the "cluster" command 701; the system 101 will display the objects 106 in that directory in clusters 402.

SETTING PARAMETERS

Figure 8 shows an example explorer user interface screen, as viewed by an operator, in which settings may be set by the operator.

In a preferred embodiment, the operator 108 may select settings appropriate for the system 101. The operator 108 may select a "properties" command 801 in the query window 601 (figure

6), and the system 101 will display a properties window 802 with a set of property values 803 which may be set.

A "minimum rank of returned hits" property 804 is a threshold value for including matched objects 106; matched objects 106 whose rank falls below this value are not displayed in the results window 602 and are not used in further processing. The rank of a matched object 106 is calculated by the CBR engine 110. In the example, this value is set to 80.

A "maximum clustered hits" property 805 is a maximum number of matched objects 106 which are included in a single cluster 402. Those matched objects 106 not included in clusters 402 are placed in a special cluster 402 labelled "Other". In the example, this value is set to 400.

A "clustering time" property 806 is the elapsed real time devoted to clustering. In the example, this value is set to 2500 milliseconds.

A "minimum number of clusters" property 807 is the lower bound for the number of clusters 402 generated. In the example, this value is set to 2 clusters.

A "maximum number of clusters" property 808 is the upper bound for the number of clusters 402 generated. In the example, this value is set to 8 clusters. The system 101

attempts to generate a number of clusters 402 between the minimum and maximum number selected.

A "maximum topics" property 809 is the maximum number of topics displayed in the topics field 609 in the query window 601. In the example, this value is set to 7 topics.

A "maximum subtopics" property 810 is the maximum number of subtopics displayed in the subtopics window 610. In the example, this value is set to 250 subtopics.

A "do/don't cluster" property 811 sets whether or not clustering is performed. In the example, this value is set to YES.

A "do/don't generate query topics" property 812 sets whether or not topics and subtopics are generated in response to query terms 310. In the example, this value is set to YES.

A "do/don't generate salient topics" property 813 sets whether or not topics and subtopics are generated in response to relevant words 211. In the example, this value is set to YES.

A "boolean/vector query" property 814 sets whether the object file system 107 performs a boolean query or a vector query in response to the explorer 105. In the example, this value is set to vector queries. A boolean query would have boolean connectors (e.g., "AND", "OR") coupling the query terms 310, so

that the query 104 would not be as flexibly matched. Search using boolean queries is well known in the art.

APPENDICES

Appendix A shows a table of parts of speech and a set of lexical rules for the English language, which may be used for the tag-and-segment-text process or the tag-and-segment-text process in a preferred embodiment.

Appendix B shows an output of a test run of an example filter when applied to a portion of an example multimedia encyclopedia used as a database, available as "Microsoft Encarta" from Microsoft Corporation of Redmond, Washington.

Alternative Embodiments

While preferred embodiments are disclosed herein, many variations are possible which remain within the concept and scope of the invention, and these variations would become clear to one of ordinary skill in the art after perusal of the specification, drawings and claims herein.

APPENDIX A

Number of original entries from LDOCE and WordNet:

2466 lines of the form: Ability: skill, faculty, aptitude
11624 total terms on the right (downward relationships)
Terms never have their parents as children (no loops)

Parts of speech represented:

A	Adjective	strong, vivid, real
ADV	Adverb	weakly, dimly, very
AUX	Auxiliary Verb	can, shall, will
AXN	AUX not	can't, won't doesn't
BE	be	is, are, be, was
BTH	PQT/Double Conj.	both
CLN	Colon	:
CMA	Comma	,
CON	Connective	and, or, but
CRD	Cardinal	three, 3.14, twenty-two
D	Determiner	the, a, that
DAT	Date &/or Time	friday, 3:00, christmas
DDC	D/Double Conj.	either, neither
DO	Do (aux)	do, did, does
ENS	End Of Sentence	., ?, !, ;
ETC	"And Others"	..., etc., et.al.
GEN	Genitive	his, her, their
HAV	Have (aux)	have, had, has, having
IJ	Interjection	Oh, shucks, well
INF	Infinitive marker	to
N	Noun	frog, pride, year
NEG	Negation	not
ORD	Ordinal	first, 2nd, last
P	Preposition	by, around, with, from
PA	Open Paren	(, [, {, <
PD	Post Determiner	many, several, next,
PN	Proper Noun	Zippy, Brad Allen
PQL	Pre-Qualifier	quite, rather, such

PQT	- Pre-Quantifier	nary, many, half, all
PRN	- Pronoun	him, she, we
PRT	- Participial Verb	running, thinking
QA	- Quantifier/Article	that, this
QL	- Qualifier	some, many, every,
QLP	- Post-Qualifier	enough, 'nuff, indeed
QN	- Quantified Noun	everybody, nothing
REN	- Close Paren	),], }, >
RP	- Relative Pronoun	that, which
SOS	- Start of Sentence,	or "
V	- Verb (inf or past)	eat, voted, surf
WHD	- Wh-Determiner	what, which
WHQ	- Wh-Qualifier	who,why
XT	- Existential Term	it, there

Total number of phrase recognition rules:

5 for the filter:

A|CRD|GEN|N|ORD, N, ~N
GEN, PRT
A|ADV|CRD|GEN|N|ORD, A|CRD|N|ORD, N, ~N
A|ADV|CRD|GEN|N|ORD, A|CRD|N|ORD, A|CRD|N|ORD, N, ~N
A|CRD|N|ORD, CON, A|CRD|N|ORD, N, ~N

Additional 10 for the Explorer (original 5 used as well):

N, P, N, ~N
N, RP, V, ~(A|D|N|PN)
N, P, D|PD, N, ~N
N, RP, N|PN|V, N|PN|V
N, RP, AUX|AXN|COP|DO|HAV, A|PRT|V, ~(A|CRD|D|N|ORD|PN)
A|ADV|CRD|GEN|N|ORD, A|CRD|N|ORD, A|CRD|N|ORD, A|CRD|N|ORD, N, ~N
N, P, D|PD, A|CRD|N|ORD, N, ~N
N, RP, V, A|CRD|D|N|ORD|PD, N
N, RP, A|CRD|D|N|ORD|PD, N, V

N, RP, AUX|AXN|COP|DO|HAV, P|PRT|V, N|PN

note: ~X means not X or nothing at all (end of sentence)

Total number of automatically acquired lexicon entries:

For Encarta, including base LDOCE/Wordnet entries:

184904 unique words / base phrases
51623 parents involved in 445025 relationships
151850 children involved in 445025 relationships

Average number of terms per automatically acquired phrase:

445025 / 51623 = 8.6
445025 / 151850 = 2.9

Average number of children phrases from original LDOCE entries:

11624 / 2466 = 4.7

NOTE from Perry:

You asked how many things we got out of WordNet and LDOCE. The number that David responded was the number of taxonyms we extracted from those two sources (mostly WordNet). If you were asking the number of words we extracted, it was initially in the neighborhood of 85,000. The current number of tagged words in the lexicon is 25915.

There are some additional phrase lattice rules that David didn't mention, since they are currently stubbed out. They involve noun phrases where a prepositional phrase or relative clause attatches to the right of a noun:

Queen of England
girl from Ipanema

WO 95/02221 PCT/US94/07569

man who hit Dave Adam
car that didn't stop

The reason why we don't use them is because of the right attatchment. Our current representation in the phrase lattice file is:

base-word, ext1, ext2, ... , extn

where ext1 through extn all attatch to the LEFT of base-word. Bear in mind, of course, that unstubbing the code and fixing the reps of this file will add this form of phrase lattice entry, but it will also increase the size of the phrase lattice file (perhaps double it).

LDOCE is basically a dictionary of British English, so we found a lot of words we weren't familiar with, as well as a lot of double entries to account for American spellings (e.g. color and colour). The lexical categories we were able to extract out of LDOCE and WordNet were limited to nouns, verbs, adjectives, adverbs, conjunctions, determiners, predeterminers, prepositions, pronouns, and phrases. Since we don't use a phrasal lexicon, we threw the phrases away.

All other categories of words (including the different categories of verbs: do, be, have, participial) were hand tagged. This tagging was greatly aided by two books: DeRose's Dissertation and the book by Kucera and Francis. The past tenses for all verbs were also done by hand, which was something of a waste as most of them (the regular ones) were eventually thrown away, once we implemented rules that tag based on word endings.

The following are the current set of rules used for determining noun phrases:

1. noun-phrase --> proper-noun (e.g. "Elvis")
2. noun-phrase --> pronoun (e.g. "he")
3. noun-phrase --> noun (e.g. "cars")
4. noun-phrase --> gerund (e.g. "running")
5. noun-phrase --> determiner noun-phrase (e.g. "The person")
6. noun-phrase --> quantifier noun-phrase (e.g. "Three people")
7. noun-phrase --> adjective noun-phrase (e.g. "fluffy clouds")
8. noun-phrase --> adverb noun-phrase (e.g. "maddeningly fluffy clouds")
9. noun-phrase --> noun noun-phrase (e.g. "printer ribbons")
10. noun-phrase --> noun-phrase relative-clause (e.g. "The car that hit me")
11. noun-phrase --> noun-phrase prepositional-phrase
    (e.g. "The person with the most toys")
12. noun-phrase --> noun-phrase that sentence
    (e.g. "The candidate that I will vote for")
13. noun-phrase --> noun-phrase [, noun-phrase]* [,] and noun-phrase
    (e.g. "Larry, Moe and Curly")
14. noun-phrase --> noun-phrase [, noun-phrase]* [,] or noun-phrase
    (e.g. "England, France, or Germany")
15. noun-phrase --> comparative noun-phrase than noun-phrase
    (e.g. "more tea than China")

The *Find Taxonomic Relations* process (process 2.2 in figure 4) uses ART-IM rules to capture patterns of words which indicate taxonomic relationships between the words. For example, it detects patterns like:

"... kangaroos, wallabies, and other marsupials ..."

From this particular phrase, one could reasonably extract the relations

IS_A(kangaroo,marsupial) and
IS_A(wallaby,marsupial)

Other patterns which detect this type of relation extracted from [14] are :

1. *NP such as {NP,}* {(and | or) } NP*
2. *such NP as {NP,}* {(and | or) } NP*
3. *NP {, NP}* {,} and other NP*
4. *NP {, NP}* {,} or other NP*
5. *NP {,} including {NP,}* {(and | or) } NP*
6. *NP {,} especially {NP,}* {(and | or) } NP*

APPENDIX B

```
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Clustering file afl.txt
Non-empty clusters: 5
Clusters: 5
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0    1    0 NONE
  1    2    0 Reuther, Walter Philip, Labor, labor:2, president:2, wage:2
  2    2    0 Railroad Labor Organizations, Brotherhood, Union, united states:2,
  3    7    0 Hillman, Sidney, Labor, labor:7, afl:7, union:4, american federati
  4    2    0 Kirkland, Lane, Labor, director:2
Passes: 1029, best pass: 830, best score: 0.955, worst score: 0.170
Cluster 0, has 1 hits: ''
  Football, Type, United States
Cluster 1, has 2 hits: 'labor:2, president:2, wage:2'
  Meany, George, Labor
  Reuther, Walter Philip, Labor
Cluster 2, has 2 hits: 'united states:2, union:2, management:2'
  Railroad Labor Organizations, Brotherhood, Union
  Teamsters Union, Full, International Brotherhood
Cluster 3, has 7 hits: 'labor:7, afl:7, union:4, american federation:4, cio:3, o
  American Federation, Labor, Congress
  Gomper, Samuel, Labor
  Green, William, Labor
  Hillman, Sidney, Labor
  Knight, Labor, Union
  Lewi, John L, Labor
  Strike, Labor, Relation
Cluster 4, has 2 hits: 'director:2'
  Kirkland, Lane, Labor
  Rozelle, Pete, Full


Clustering file alcohol.txt
Non-empty clusters: 5
Clusters: 5
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0   15    0 (OTHER), blood:3, vitamin:2, tissue:2, poison:2, sugar metabolism:
  1   22    0 Antifreeze, Chemical, Substance, alcohol:21, acid:7, ethyl:7, liqu
  2   10    0 Vodka, Beverage, Known, alcohol:9, percent:5, beverage:5, use:3, 1
  3    6    0 Gasohol, Blend, Part, fuel:5, alcohol:2, methanol:2, combustion:2,
  4    4    0 Marijuana, Mixture, Leave, drug:3, alcohol:3, syndrome:3, psychoac
Passes: 334, best pass: 158, best score: 0.307, worst score: 0.132
Cluster 0, has 15 hits: '(OTHER), blood:3, vitamin:2, tissue:2, poison:2, sugar
  Birth Defects, Disorder, Structure
  Cancer, Medicine, Growth
  Corn, Maize, Cereal
  Crop Farming, Cultivation, Plant
  First Aid, Emergency, Measure
  Fungi, Group, Organism
  Liver, Organ, Vertebrate
  Nutrition, Human, Science
  Paint, Varnish, Liquid
  Pennsylvania, Full, Commonwealth
  Poison, Substance, Produce
```

Sugar, Term, Number

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Thermometer, Instrument, Measure
Wine, Beverage, Juice
Wood, Substance, Trunk
Cluster 1, has 22 hits: 'alcohol:21, acid:7, ethyl:7, liquid:4, example:3, chemi
Acetaldehyde, Volatile, Liquid
Antifreeze, Chemical, Substance
Azeotropic Mixture, Solution, Ratio
Butyl Alcohol, Chemical, Formula
Cannizzaro, Stanislao, Italian
Disease, Medicine, Health
Ester, Chemistry, Compound
Ether, Chemistry, Ethyl
Fermentation, Chemical, Change
Formaldehyde, Compound, Carbon
Glycerin, Glycerol, C3h8o3
Gum, Substance, Plant
Iodine, Element, Symbol
Lipid, Group, Substance
Salicylic Acid, White, Solid
Solution, Chemistry, Mixture
Tannin, Acid, Name
Turpentine, Name, Semifluid
Vinegar, Condiment, Preservative
Wax, Name, Ester
Whiskey, Liquor, Mash
Zymology, Zymurgy, Biochemistry
Cluster 2, has 10 hits: 'alcohol:9, percent:5, beverage:5, use:3, liquor:3, dist
Beer, Term, Beverage
Cider, Sweet, Juice
Cosmetic, Term, Preparation
Distillation, Process, Liquid
Distilled Liquors, Beverage, Alcohol
Gin, Liquor, Grain
Liqueur, Beverage, Spirit
Police, Agency, Community
Prohibition, Ban, Manufacture
Vodka, Beverage, Known
Cluster 3, has 6 hits: 'fuel:5, alcohol:2, methanol:2, combustion:2, coal:2, eng
Alcohol, Arabic, Al-kuhul
Automobile, Greek, Auto
Combustion, Process, Oxidation
Energy Supply, World, Resource
Gasohol, Blend, Part
Rocket, Term, Propulsion
Cluster 4, has 4 hits: 'drug:3, alcohol:3, syndrome:3, psychoactive drugs:2, mar
Alcoholism, Illness, Ingestion
Drug Dependence, State, Compulsion
Marijuana, Mixture, Leave
Psychoactive Drugs, Chemical, Substance

```
Clustering file bulb.txt
Non-empty clusters: 5
Clusters: 5
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------




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  0    9    0 (OTHER), plant:3, united states:2, seed:2, gardening:2, flower:2
  1   10    0 Radiometer, Instrument, Intensity, bulb:7, light:4, tuber:3, stem:
  2    3    0 Electric Lighting, Illumination, Mean, lamp:3, glass:2, neon:2, ar
  3    5    0 Autumn Crocus, Name, Herb, bulb:5, liliaceae:4, herb:3, lily:3, pi
  4    6    0 Hygrometer, Type, Instrument, temperature:4, atmosphere:3, point:3
Passes: 598, best pass: 333, best score: 0.491, worst score: 0.208
Cluster 0, has 9 hits: '(OTHER), plant:3, united states:2, seed:2, gardening:2,
  Disease, Plant, Deviation
  Gardening, Cultivation, Plant
  Garlic, Name, Herb
  Genetics, Study, Trait
  Gopher, French, Gauffre
  Horticulture, Latin, Hortu
  Peanut Worm, Name, Small
  Spice, Flavoring, Part
  Technology, Term, Process
Cluster 1, has 10 hits: 'bulb:7, light:4, tuber:3, stem:3, rhizome:3, electron:2
  Bulb, Mass, Leave
  Edison, Township, Middlesex County
  Edison, Thomas Alva, Inventor
  Onion, Name, Herb
  Photoelectric Cell, Phototube, Electron
  Photography, Technique, Permanent
  Radiometer, Instrument, Intensity
  Rhizome, Stem, Organ.
  Tuber, Stem, Plant
  Ray, Radiation, Wavelength
Cluster 2, has 3 hits: 'lamp:3, glass:2, neon:2, arc:2, bulb:2, argon:2, light:2
  Argon, Element, Symbol
  Electric Lighting, Illumination, Mean
  Neon Lamp, Glass, Bulb
Cluster 3, has 5 hits: 'bulb:5, liliaceae:4, herb:3, lily:3, pistil:2, height:2,
  Autumn Crocus, Name, Herb
  Hyacinth, Plant, Genu
  Soap Plant, Amole, Native
  Star-of-bethlehem, Name, Herb
  Tuberose, Herb, Polianth
Cluster 4, has 6 hits: 'temperature:4, atmosphere:3, point:3, humidity:2, bulb:2
  Blood Pressure, Pressure, Blood
  Humidity, Moisture, Content
  Hygrometer, Type, Instrument
  Meteorology, Study, Atmosphere
  Thermometer, Instrument, Measure
```

```
  Vapor, Physic, Term


Clustering file columbus.txt
Non-empty clusters: 7
Clusters: 7
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0    4    0 (OTHER), century:2
  1    4    0 Pinzn, Name, Family, expedition:3, voyage:2, hispaniola:2, pinta:2
  2    5    0 Puerto Rico, Commonwealth, Spanish Estado Libre Asociado, spanish:
  3    2    0 Samana Cay, Island, Bahama, atlantic ocean:2, landfall:2, san salv
  4    6    0 Mississippi, East South Central, U.S., state:5, river:3, city:3, a
```



```
  5    5    0 Santiago, Dominican Republic, Name, cacao:3, city:3, caribbean:2,
  6    4    0 South America, Continent, Asia, death valley:2, south:2, slavery:2
Passes: 614, best pass: 65, best score: 0.520, worst score: 0.189
Cluster 0, has 4 hits: '(OTHER), century:2'
  American Literature, Literature, English
  Coln, Geography, City
  Europe, Continent, World
  Knight, Columbu, Organization
Cluster 1, has 4 hits: 'expedition:3, voyage:2, hispaniola:2, pinta:2, ship:2'
  Columbu, Christopher, Italian Cristoforo Colombo
  Pinzn, Name, Family
  Ship, Type, Construction
  Velzquez, Diego, Soldier
Cluster 2, has 5 hits: 'spanish:4, island:3, spain:2, de:2, christopher columbus
  Bobadilla, Francisco, De
  Cuba, Island, West Indies
  Dsirade, Island, West Indies
  Ferdinand V, The Catholic, King
  Puerto Rico, Commonwealth, Spanish Estado Libre Asociado
Cluster 3, has 2 hits: 'atlantic ocean:2, landfall:2, san salvador:2, island:2,
  Samana Cay, Island, Bahama
  San Salvador, Island, Watling Island
Cluster 4, has 6 hits: 'state:5, river:3, city:3, american civil war:2, ohio:2,
  Columbu, Georgia, City
  Columbu, Mississippi, City
  Columbu, Ohio, City
  Georgia, State, South Atlantic
  Mississippi, East South Central, U.S.
  Ohio, East North Central, U.S.
Cluster 5, has 5 hits: 'cacao:3, city:3, caribbean:2, dominican:2, santiago:2, c
  Columbu, Indiana, City
  Santiago, Dominican Republic, Name
  Santo Domingo, Trujillo, City
  Spanish Town, City, Jamaica
  Tobago, Republic, Commonwealth
Cluster 6, has 4 hits: 'death valley:2, south:2, slavery:2, brazil:2, continent:
  Black, America, Immigration
```

```
  North America, Contin. .c  Canada
  South America, Continent, Asia
  United States, America, Republic


Clustering file dualism.txt
Non-empty clusters: 5
Clusters: 5
#   Hits Vals Seed, Value:Count
--- ---- ---- -----------------
  0    2    0 NONE
  1    5    0 Dualism, Philosophy, Theory, mind:5, philosopher:5, philosophy:3,
  2    3    0 Devil, Hebrew, Belief, evil:3, god:3, good:2, human:2, middle ages
  3    3    0 Paulician, Church, History, dualism:3, sect:3, bogomils:2, old tes
  4    2    0 Docetism, Christian, Heresy, doctrine:2, human:2
Passes: 1050, best pass: 312, best score: 1.003, worst score: 0.397
Cluster 0, has 2 hits: ''
  Austria, German, sterreich
  Zoroastrianism, Religion, Persia



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Cluster 1, has 5 hits: 'mind:5, philosopher:5, philosophy:3, matter:3, universe:
  Dualism, Philosophy, Theory
  Metaphysics, Branch, Philosophy
  Monism, Greek, Mono
  Occasionalism, Term, System
  Philosophy, Greek, Philosophia
Cluster 2, has 3 hits: 'evil:3, god:3, good:2, human:2, middle ages:2, middle ea
  Albigens, Follower, Single
  Devil, Hebrew, Belief
  Evil, Wrong, Harm
Cluster 3, has 3 hits: 'dualism:3, sect:3, bogomils:2, old testament:2, century:
  Basilide, Teacher, Alexandria
  Bogomils, Member, Sect
  Paulician, Church, History
Cluster 4, has 2 hits: 'doctrine:2, human:2'
  Docetism, Christian, Heresy
  Neoplatonism, Designation, Doctrine


Clustering file infant.txt
Non-empty clusters: 7
Clusters: 7
#   Hits Vals Seed, Value:Count
--- ---- ---- -----------------
  0    4    0 NONE
  1    3    0 Gesell, Arnold Lucius, Psychologist, infant:3, development:2
  2    2    0 Incubator, Apparatu, Chamber, growth:2
  3    2    0 Pregnancy, Childbirth, Term, birth:2, pregnancy:2, infant:2, child
  4    2    0 Hondura, Republic, Central America, country:2, 1980s:2
  5    3    0 Baptism, Greek, Baptein, rite:2, baptism:2
  6    2    0 Japan, Japanese Dai, Great, manchuria:2, government:2, party:2
```

```
Passes: 835, best pass:  7   best score: 0.795, worst sc    : 0.274
Cluster 0, has 4 hits:
  Free Trade, Interchange, Frontier
  Human, Name, Individual
  Perception, Process, Stimulation
  Scotland, Division, Kingdom
Cluster 1, has 3 hits: 'infant:3, development:2'
  Gesell, Arnold Lucius, Psychologist
  Infancy, Period, Birth
  Sudden Infant Death Syndrome, Sid, Death
Cluster 2, has 2 hits: 'growth:2'
  Incubator, Apparatu, Chamber
  Population, Term, Human
Cluster 3, has 2 hits: 'birth:2, pregnancy:2, infant:2, childbirth:2, women:2'
  Obstetrics, Branch, Medicine
  Pregnancy, Childbirth, Term
Cluster 4, has 2 hits: 'country:2, 1980s:2'
  Hondura, Republic, Central America
  Sierra Leone, Nation, Africa
Cluster 5, has 3 hits: 'rite:2, baptism:2'
  Baptism, Greek, Baptein
  Circumcision, Removal, Part
  Mennonite, Religious, Group
Cluster 6, has 2 hits: 'manchuria:2, government:2, party:2'
  China, Chinese Zhonghua Renmin Gongheguo, People Republic
```



```
  Japan, Japanese Dai, Great


Clustering file israel.txt
Non-empty clusters: 4
Clusters: 4
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0   22    0 (OTHER), government:6, war:4, century:3, french revolution:3, coun
  1   66    0 Judah, Old Testament, Name, israel:64, judah:20, old testament:20,
  2   39    0 Nasser, Gamal Abdel, Egyptian, israel:32, arab:26, israeli:20, pal
  3   11    0 Song, Solomon, Book, book:10, old testament:9, israel:9, chap:5, b
Passes: 127, best pass: 117, best score: 0.213, worst score: 0.083
Cluster 0, has 22 hits: '(OTHER), government:6, war:4, century:3, french revolut
  Achille Lauro, Italian, Cruise
  Anti-semitism, Social, Agitation
  Asia, Continent, Island
  Assyria, Ashur, Ashshur
  Bahai, Persian, Glory
  Buber, Martin, Religious
  Cabala, Hebrew, Tradition
  Crusade, Expedition, Undertaken
  Eschatology, Discourse, Last
  Espionage, Collection, Information
  Iran, Islamic Republic, Republic
```

Jewish Art, Architect ‹ Jew
Jewish Music, Religic ›, Music
Nationalism, History, Movement
Portuguese Literature, Literature, Portuguese
Refugee, Person, Country
Romania, Republic, Europe
Saudi Arabia, Monarchy, Southwest Asia
Union, Soviet Socialist Republics, Russian Soyuz Sovyetskikh Sotsialisticheski
United Nations, Organization, Nation-state
United States, America, Republic
Woman Suffrage, Right, Women
Cluster 1, has 66 hits: 'israel:64, judah:20, old testament:20, king:18, bc:12,
Abner, Old Testament, Cousin
Ahab, King, Israel
Amaziah, Hebrew, King
Ammonite, People, Region
Amo, Book, Old Testament
Angel, Greek, Aggelo
Apostle, Greek, Apostolo
Ashqelon, Town, Palestine
Balaam, Old Testament, Prophet
Kokhba, Simon, Name
Bene Israel, Community, Jew
Ben-zvi, Itzhak, Second
Bethlehem, Jordan, Hebrew
Bible, Holy Bible, Book
Carmel, Mount, Mountan
Diaspora, Greek, Dispersion
David, King, Bc
Edom, Old Testament, Times
Elat, Eilat, City

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Elia, Century, Bc
Elisha, Old Testament, See
Ephraim, Hebrew, Old Testament
Esdraelon, Plain, Jezreel
Ezekiel, Book, Old Testament
Falasha, Sect, Ethiopia
Galilee, Galil, Circle
Gideon, Hebrew, Hewer
Habima Theater, Former, Name
Hebron, City, Israeli-occupied Jordan
Herzog, Chaim, President
High Priest, Hierarchy, Head
Holon, City, Israel
Israel, Kingdom, Hebrew
Jacob, Old Testament, Patriarch
Joash, Name, King
Jehoshaphat, Hebrew, Jehovah
Jehu, Hebrew, Jehovah
Jeremiah, Book, Old Testament

Jeroboam I, Old Testament. See
Jeroboam Ii, King, Israel
Jew, Usage, Hebrews
Jezebel, Tyrian, Princess
Jonathan, Old Testament Books, Samuel
Judah, Old Testament, Name
Judaism, Culture, Jew
Justification, Theology, Way
King, Book, Old Testament
Lost Tribes, History, Tribe
Manasseh, Son, Old Testament
Meir, Golda, Israeli
Michael, Hebrew, God
Moab, Country, Hill
National Jewish Welfare Board, National, Agency
Negeb, Region, Middle East
Philistine, Inhabitant, Region
Putnam, Israel, Soldier
Ramat Gan, City, Central
Rehoboam, King, Judah
Samuel, Book, Old Testament
Saul, King, Israel
Sharon, Plain, Israel
Shema, Hebrew, Word
Solomon, King, Israel
Tiberia, Lake, Sea
Weizmann, Chaim, Long-time
Zangwill, Israel, English
Cluster 2, has 39 hits: 'israel:32, arab:26, israeli:20, palestine:11, egypt:11,
Husein, King, Jordan
Acre, Akko, Seaport
Agnon, Shmuel Yosef, Israeli
Amman, Rabbah Ammon, Philadelphia
Arab League, Name, League
Arafat, Yasir, Palestinian
Aren, Moshe, Israeli
Menachem, Israeli, Prime

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Ben-gurion, David, Israeli
Damascu, Arabic Dimashq, Ash-sham
Dayan, Moshe, Israeli
Egypt, Arab Republic, United Arab Republic
Gaza, Arabic Ghazze, City
Golan Heights, Region, Syria
Haifa, City, Seaport
Hebrew Literature, Literature, Jew
Iraq, Irak, Republic
Israel, Republic, Middle East
Jerusalem, Arabic, Al-qud
Jordan, River, Middle East
Jordan, Hashemite Kingdom, Arabic

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  Kibbutz, Village, Far
  Lebanon, Arabic Lubnan, Republic
  Libya, Full, Socialist People Libyan Arab Jamahiriyah
  Middle East, Region, Geography
  Nasser, Gamal Abdel, Egyptian
  Palestine, Region, Extent
  Palestine Liberation Organization, Plo, Body
  Sadat, Egyptian, Military
  Six-day War, Conflict, June
  Suez Canal, Waterway, Running
  Syria, Arabic Suriyah, Al-arabiyah
  Tel Aviv-jaffa, Tel Aviv-yafo, City
  Terrorism, International, Use
  Tunisia, Republic, Africa
  West Bank, Area, West
  Yom Kippur War, Conflict, Israel
  Zionism, Movement, People
  Zionist Organization, America, Zoa
Cluster 3, has 11 hits: 'book:10, old testament:9, israel:9, chap:5, bc:5, proph
  Dead Sea Scrolls, Collection, Hebrew
  Hosea, Book, Old Testament
  Isaiah, Book, Old Testament
  Joshua, Book, Old Testament
  Judge, Book, Old Testament
  Micah, Book, Old Testament
  Number, Book, Old Testament
  Obadiah, Book, Old Testament
  Song, Solomon, Book
  Wisdom, Solomon, Book
  Zechariah, Book, Old Testament


Clustering file marx.txt
Non-empty clusters: 6
Clusters: 6
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0    2    0 (OTHER), german:2, germany:2, east:2, baltic sea:2
  1    3    0 Hegel, G, W, philosopher:3, philosophy:2
  2    4    0 Bolshevism, Doctrine, Theory, communist:4, lenin:4, revolution:3,
  3    4    0 Marx Brothers, 20th-century, Comedian, marx:4, socialism:2, engels
  4    4    0 Communist Manifesto, German Manifest, Partei, capitalist:3, class:
  5    6    0 Ideology, System, Concept, social:3, marx:3, labor:2, world war ii



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Passes: 722, best pass: 675, best score: 0.663, worst score: 0.248
Cluster 0, has 2 hits: '(OTHER), german:2, germany:2, east:2, baltic sea:2'
  Germany, Country, Europe
  Germany, German Democratic Republic, Gdr
Cluster 1, has 3 hits: 'philosopher:3, philosophy:2'
  Hegel, G, W
  Philosophy, Greek, Philosophia
```

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  Political Theory, Sub   ion, Science
Cluster 2, has 4 hits: 'communist:4, lenin:4, revolution:3, communism:2, governm
  Bolshevism, Doctrine, Theory
  Communism, Concept, System
  International, Name, Socialist
  Socialism, Doctrine, Movement
Cluster 3, has 4 hits: 'marx:4, socialism:2, engels:2'
  Bernstein, Eduard, German Social Democratic
  Economics, Science, Production
  Engels, Friedrich, German
  Marx Brothers, 20th-century, Comedian
Cluster 4, has 4 hits: 'capitalist:3, class:3, capitalism:2, communist:2, bourge
  Bourgeoisie, Resident, European
  Capitalism, System, Individual
  Communist Manifesto, German Manifest, Partei
  Marx, Karl, German
Cluster 5, has 6 hits: 'social:3, marx:3, labor:2, world war ii:2, german:2, cen
  Ideology, System, Concept
  Karl-marx-stadt, Former, Name
  Kautsky, Karl Johann, German Marxist
  Lassalle, Ferdinand, German
  Sociology, Science, Deal
  Wage, Theory, Labor


Clustering file muslim.txt
Non-empty clusters: 4
Clusters: 4
#   Hits Vals Seed, Value:Count
--- ---- ---- ------------------
  0   41    0 (OTHER), arab:7, bc:5, ibn:4, indian:4, india:4, islam:4
  1   20    0 Philippine, Republic, Pacific Ocean, 1980s:17, country:8, governme
  2   40    0 Kashgar, Kashi, Kaxgar, muslim:38, india:8, muhammad:7, jerusalem:
  3   11    0 Mathematics, Study, Relationship, century:11, art:3, france:3, arc
Passes: 146, best pass: 47, best score: 0.210, worst score: 0.124
Cluster 0, has 41 hits: '(OTHER), arab:7, bc:5, ibn:4, indian:4, india:4, islam:
  Alfonso Viii, King, Castile
  Arabia, Desert, Peninsula
  Arabic Literature, Literature, People
  Archaeology, Greek, Archaio
  Averros, Arabic, Abu
  Black Muslims, Religious, Organization
  Borneo, Island, World
  Chess, Game, Skill
  Christianity, World, Religion
  Chronology, Science, Division
  Concubinage, Term, World
  Costume, Clothing, People
  Demon, Usage, Spirit
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  Egypt, Arab Republic, United Arab Republic
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Gandhi, Mohandas Karar .. 1, Mahatma Gandhi
Ghana, Kingdom, West ..can
Hegira, Hejira, Arabic
Iraq, Irak, Republic
Jacobite Church, Christian, Group
Java, Island, Malay Archipelago
Jew, Usage, Hebrews
Jordan, Hashemite Kingdom, Arabic
Judaism, Culture, Jew
Karbala, City, Iraq
Mahdi, Arabic, Mahdiy
Medina, Medinat-en-nabi, City
Middle East, Region, Geography
Nehru, Indian, Nationalist
Orthodox Church, Major, Branch
Philosophy, Greek, Philosophia
Pottery, Clay, Firing
Punjab, Region, River
Saudi Arabia, Monarchy, Southwest Asia
Shiite, Arabic, Partisan
Sikhs, Follower, Religion
Sudan, Republic, Africa
Trigonometry, Branch, Mathematics
Tobago, Republic, Commonwealth
Tunisia, Republic, Africa
Turkey, Republic, Turkish Trkiye Cumhuriyeti
Vijayanagar, Kingdom, India
Cluster 1, has 20 hits: '1980s:17, country:8, government:7, spanish:5, arab:4, s
Afghanistan, Persian Afghnistn, Republic
Bangladesh, Full, People Republic
Berber, Name, Language
Cameroon, Republic, Africa
Chad, Republic, Central
Ethiopia, Abyssinia, Republic
Gambia, Republic, Commonwealth
Gibraltar, Dependency, Promontory
Indonesia, Republic, Island
Iran, Islamic Republic, Republic
Israel, Republic, Middle East
Kenya, Republic, Africa
Libya, Full, Socialist People Libyan Arab Jamahiriyah
Morocco, Arabic, Al-mamlakah
Nigeria, Federal Republic, Republic
Pakistan, Islamic Republic, Republic
Philippine, Republic, Pacific Ocean
Republic, Europe, Portion
Spain, Spanish Espaa, Monarchy
Syria, Arabic Suriyah, Al-arabiyah
Cluster 2, has 40 hits: 'muslim:38, india:8, muhammad:7, jerusalem:5, delhi:4, p
Fakhruddin Ali, Fifth, President
Algeria, French Algrie, Popular Republic
Allah, Name, Supreme Being
Almeida, Francisco, De
Almoravid, Berber, Dynasty
Asia, Continent, Island

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  Babism, Religion, Offshoot
  Balewa, Sir Abubakar Tafawa, Minister
  Region, Part, Subcontinent
  Caliphate, Office, Realm
  Crusade, Expedition, Undertaken
  Delhi, Old Delhi, City
  Delhi Sultanate, Muslim, State
  Dervish, Turkish, Darvsh
  Fakir, Arabic, Faqir
  Farabi, Tarkhan, Al-farabi
  Gansu, Kansu, Province
  Ghazali, Name, Abu Hamid Muhammad
  India, Republic, Hindi Bharat
  Sir Muhammad, Pakistani, Philosopher
  Islam, World, Religion
  Islamic Music, Vocal, Art
  Jammu, Kashmir, Known
  Jerusalem, Arabic, Al-qud
  Jinnah, Muhammad Ali, Leader
  Kashgar, Kashi, Kaxgar
  Kharijite, Arabic, Kharawrij
  Lebanon, Arabic Lubnan, Republic
  Malaysia, Monarchy, Commonwealth
  Malcolm X, Leader, Omaha
  Mufti, Title, Lawyer
  Palestine, Region, Extent
  Pilgrim, Place, Intent
  Relic, Usage, Body
  Roger I, Norman, Conqueror
  Saladin, Leader, Jerusalem
  Shivaji Bhonsle, Founder, India Maratha State
  Tughluq, Muhammad, Sultan
  Tuni, Tune, City
  Umar, Al-hajj, West African
Cluster 3, has 11 hits: 'century:11, art:3, france:3, architecture:2, sculpture:
  Africa, Continent, Island
  Europe, Continent, World
  France, French Rpublique Franaise, Republic
  Gypsy, People, Heritage
  History, Historiography, Sense
  Indian Art, Architecture, Art
  Indian Literature, Literature, Language
  Islamic Art, Architecture, Art
  Library, Repository, Form
  Mathematics, Study, Relationship
  Portraiture, Representation, Art


Clustering file pope.txt
Non-empty clusters: 3
Clusters: 3
#   Hits Vals Seed, Value:Count
--- ---- ---- -----------------
  0   50    0 (OTHER), church:12, henry:8, king:7, english:6, roman:6, governmen
  1  138    0 Benedict Xiv, Pope, Moderation, pope:138, church:28, rome:26, coun
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2 12 0 Angelico, r Italian, florence:10, medic , florentine:4, domin

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Passes: 86, best pass: 34, best score: 0.149, worst score: 0.082
Cluster 0, has 50 hits: '(OTHER), church:12, henry:8, king:7, english:6, roman:6
Aquina, Saint Thomas, Angelic Doctor
Borgia, Cesare, Italian
Bruno, Saint, Carthusian
Bulgaria, Full, People Republic
Canon Law, Greek, Kanon
Carpini, Giovanni, De
Carroll, John, American Roman Catholic
Christianity, World, Religion
Church, England, Anglican Church
Civil War, Conflict, United States
Conrad Iii, King, Germany
Corsica, French Corse, Island
Counter Reformation, Movement, Roman Catholic
Couplet, Poetry, Term
Cranmer, Thoma, Archbishop
Cyril, Methodiu, Saint
Demarcation, Line, Boundary
Duns Scotus, John, Theologian
Easter, Festival, Resurrection
England, Latin Anglia, Portion
English Literature, Literature, England
Erigena, John Scotus, Scholar
Este, Italian, Family
Europe, Continent, World
Felix V, Last, Antipope
Ferdinand I, Naple, King
Feuillant, French, Organizations-one
Finland, Finnish Suomi, Republic
Fisher, Saint John, English Christian
France, French Rpublique Franaise, Republic
Gardiner, Stephen, English
Germany, Country, Europe
Henry Viii, King, England
Henry Iv, France, Bourbon
Holy Roman Empire, Entity, Europe
Hungary, Hungarian Magyarorszg, Republic
Ireland, Geography, Island
Italian Italia, Republic, Europe
Knight, Saint John, Jerusalem
Lincoln, Abraham, President
Loyola, Saint Ignatius, Spanish Inigo
Lutheranism, Protestant, Denomination
Mary, Virgin Mary, Mother
Mendelssohn, Mos, German
Middle Ages, Period, European
Modernism, Theology, Philosophy
Neri, Saint Philip, Italian

Orthodox Church, Majo. . inch
Poland, Republic, Polska Rzeczpospolita
Pole, Reginald, English Roman Catholic
Cluster 1, has 138 hits: 'pope:138, church:28, rome:26, council:23, papacy:23, h
Adrian I, Pope, Power
Adrian Iv, Pope, Englishman
Adrian Vi, Pope, Dutchman

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Alexander Iii, Pope, Authority
Alexander Vi, Pope, Worldliness
Algardi, Alessandro, Italian
Antonelli, Giacomo, Italian
Arnold, Brescia, 1100-c
Augustinian, Order, Roman Catholic
Bacon, Roger, English Scholastic
Basel, Council, Middle Ages
Bembo, Pietro, Italian
Benedict Viii, Pope, Reformer
Benedict Ix, Pope, 1032-44
Benedict Xiii, Antipope, Avignon
Benedict Xiv, Pope, Moderation
Benedict Xv, Pope, Church
Bernard, Clairvaux, Saint
Bonaventure, Saint, Theologian
Boniface, Saint, English Benedictine
Boniface Viii, Pope, Power
Boniface Ix, Pope, Papal States
Bossuet, Jacques Bnigne, French Roman Catholic
Bull, Letter, Document
Bull Run, Battle, Manassa
Callistu, Calixtus I, Saint
Callistus Ii, Calixtus Ii, Pope
Callistus Iii, Calixtus Iii, Pope
Canonization, Roman Catholic, Church
Canossa, Village, Reggio
Cardinal, Title, Latin
Catherine, Aragn, Queen
Catherine, Siena, Saint
Cedar Mountain, Battle, Military
Celestine V, Saint, Pope
Celestine Iii, Pope, Born Giacinto Bobo
Censorship, Supervision, Control
Chalcedon, Council, Emperor
Charlemagne, Latin Carolus Magnus, Charle
Charles V, Holy Roman Empire, Holy Roman
Church, State, Relationship
Clement V, Pope, Avignon
Clement Vi, Pope, Church
Clement Vii, Pope, Pontificate
Clement Vii, Antipope, Great Schism
Clement Viii, Last, Pope

Clement Xiv, Pope, Jesui
Conciliar Theory, Doctrine, Superiority
Conclave, Latin, Cum
Constance, Council, City
Coptic Church, Christian, Church
Council, Assembly, Doctrine
Crusade, Expedition, Undertaken
Damasus I, Saint, Pope
Damian, Saint Peter, Doctor
Doctor, Church, Christian
Dllinger, Johann Joseph Ignaz, Von
Ecumenical Movement, Movement, Cooperation
Edmund, Abingdon, Saint

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Elector, German Imperial, German Kurfrsten
Eugene Iii, Pope, Cistercian
Eugene Iv, Pope, Dispute
Formosu, Pope, Trial
Franciscan, Order, Friars Minor
Frederick I, Holy Roman Empire, Frederick Barbarossa
Frederick Ii, Holy Roman Empire, Holy Roman
Gallicanism, History, Combination
Gregory I, Saint, Pope
Gregory Ii, Saint, Pope
Gregory Vii, Saint, Pope
Gregory Ix, Pope, Inquisition
Gregory Xi, Pope, Return
Guiscard, Robert, Norman
Henry Ii, Holy Roman Empire, Henry The Saint
Henry Iv, Holy Roman Empire, Holy Roman
Henry V, Holy Roman Empire, German
Hippolytu, Rome, Saint
Honorius I, Pope, Heretic
Infallibility, Theology, Doctrine
Innocent Iii, Pope, Pop
Innocent Iv, Pope, Dominion
Innocent Xi, Pope, King Louis Xiv
Inquisition, Institution, Papacy
Interdict, Roman Catholic, Church
Investiture Controversy, Dispute, Church
Jesuit, Society, Jesu
Joan, Pope, Female
John Ii, Pope, Born Mercurius
John Viii, Pope, Ablest
John Xii, Pope, Boy Pope
John Xxi, Pope, Pontiff
John Xxii, Pope, Second
John Xxiii, Antipope, Born Baldassare Cossa
John Xxiii, Pope, Era
John, John Lackland, King
John Paul I, Pope, Born Albino Luciani

John Paul Ii, Pope, N . lian
Jubilee, Jew, Sabbatical
Julius Ii, Pope, Reign
Kulturkampf, German, Culture
Langton, Stephen, English
Lateran Councils, Council, Roman Catholic
Lateran Treaty, Designation, Agreement
Leo Iii, Saint, Pope
Leo Ix, Saint, Pope
Leo X, Pope, Renaissance
Leo Xiii, Pope, Modern
Louis Iv, German, Ludwig Iv
Lyon, Council, Church
Martin I, Saint, Pope
Martin Iv, Pope, Born Simon
Martin V, Pope, Election
Molino, De, Spanish Roman Catholic
Nicholas Iii, Pope, Papal States
Nichola, Cusa, German

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Occam, William, 1285-1349
Otto Iii, Holy Roman, Emperor
Otto Iv, Otto, Brunswick
Papacy, Office, Pope
Papal States, Church, Pontifical States
Paschal Ii, Pope, Reign
Paul V, Pope, Born Camillo Borghese
Paul Vi, Pope, Second Vatican Council
Pepin, Short, Mayor
Peter Pence, Offering, Pope
Philip Iv, France, The Fair
Photiu, 820-91, Patriarch
Pico Della Mirandola, Giovanni, Conte
Pius Ii, Pope, Writer
Pius Iv, Pope, Conclusion
Pius V, Saint, Pope
Pius Vi, Pope, Reign
Pius Vii, Pope, Napoleon
Pius Ix, Pope, Pontificate
Pius X, Saint, Pope
Pius Xi, Pope, Path
Pius Xii, Pope, World War Ii
Pope, Latin, Papa
Cluster 2, has 12 hits: 'florence:10, medici:5, florentine:4, dominican:3, churc
Alberti, Leon Battista, Italian
Albertus Magnus, Saint, Albert
Angelico, Fra, Italian
Cellini, Benvenuto, Florentine
Dante Alighieri, Italian, Poet
Dominican, Friars Preachers, Member
Ferrara-florence, Council, Basel-ferrara-florence

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  Florence, Italian Fire..z   Florentia
  Guicciardini, Francesco, Italian
  Leonardo, Da, Vinci
  Medici, Lorenzo, De
  Michelangelo, Creator, History


Clustering file sound.txt
Non-empty clusters: 5
Clusters: 5
#   Hits Vals Seed, Value:Count
--- ---- ---- ----------------
  0   68    0 (OTHER), music:10, american civil war:6, state:6, bass:5, century:
  1   57    0 Mach Number, Aerodynamics, Mechanic, sound:51, instrument:8, pitch
  2    8    0 Letter, Vowel, English, sound:6, long:3, letter:3, sign:2, atlanti
  3   19    0 Linguistics, Study, Language, language:14, english:9, speech:6, so
  4   11    0 Vowel, English, Alphabet, sound:11, alphabet:9, letter:9, hierogly
Passes: 103, best pass: 74, best score: 0.173, worst score: 0.072
Cluster 0, has 68 hits: '(OTHER), music:10, american civil war:6, state:6, bass:
  Amati, Family, Italian
  American Indian Languages, Language, People
  American Indians, People, America
  Audiovisual Education, Planning, Preparation
  Band, Ensemble, Brass
  Transaction, Service, Consumer
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  Bird, Name, Member
  Bremerton, City, Kitsap County
  British Columbia, Province, Canada
  Bronx, Borough, New York City
  Building Construction, Procedure, Erection
  Circulatory System, Anatomy, Physiology
  Communication, Method, Receiving
  Connecticut, New England, United States
  Copyright, Body, Right
  Currency, Economics, Term
  Deep-sea Exploration, Investigation, Chemical
  Bass, Member, Violin
  Drama, Dramatic Arts, Form
  Edison, Thomas Alva, Inventor
  Encyclopedia, Encyclopaedia, Greek
  Firework, Device, Material
  Floor, Floor Coverings, Ceiling
  Folk Dance, Dance, Member
  Folk Music, Music, Performance
  Frequency, Term, Science
  Golden Globe Awards, Motion, Picture
  Harmony, Music, Combination
  Harpsichord, Italian, Cembalo
  Insect, Name, Animal
  Jazz, Type, Music
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Jet Propulsion, Thrus-, parting
Mississippi, East South Central, U.S.
Motion Picture Arts, Science, Academy
Music, Vocal, Part
Music, Western, Europe
Musical Form, Arrangement, Element
Mystic, Village, Stonington
Navigation, Science, Position
Haven, City, New Haven County
North Carolina, South Atlantic, U.S.
Ocean, Oceanography, Body
Orchestra, Ensemble, Instrument
Orchestration, Art, Musical
Philosophy, Greek, Philosophia
Pianoforte, Keyboard, Musical
Social Dance, Term, Dance
Radio, System, Communication
Rhode Island, Full, State
Scale, Music, Italian
Scott, Robert Falcon, Officer
Seattle, City, Seat
Seward Peninsula, Peninsula, Alaska
Snake, Reptile, Name
Sonata, Italian, Sonare
Tacoma, City, Seat
Telephone, Communication, Instrument
Television, Tv, Transmission
Theater Production, Mean, Form
United States, America, Republic
Valdez, City, Alaska
Video Recording, Process, Recording

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Viol, Instrument, Century
Washington, State, U.S.
Wave Motion, Physic, Mechanism
Whale, Mammal, Order
Yachting, Operation, Boat
Zither, Instrument, String
Cluster 1, has 57 hits- 'sound:51, instrument:8, pitch:7, string:5, recording:5,
Acoustics, Greek, Akouein
Aerodynamics, Branch, Mechanic
Airplane, Craft, Action
Albemarle Sound, Inlet, Atlantic Ocean
Bell, Instrument, Percussion
Chaplin, Charlie, Name
Clair, Ren, Name
Digital Audio Tape, Dat, Tape
De Forest, Lee, Inventor
Doppler Effect, Physic, Variation
Ear, Organ, Hearing
Edmond, City, Snohomish County

Electronic Music, Music, nowledge
Exxon Valdez, Oil, Tanker
Falkland Islands, Islas Malvinas, Island
Fluid Mechanics, Science, Action
Grunt, Name, Fish
Guitar, Instrument, Lute
Harmonic, Vibration, Primary
Harp, Instrument, Run
Hearing, Main, Sense
Hearing Aid, Device, Sound
Mach Number, Aerodynamics, Mechanic
Microphone, Device, Energy
Midi, Acronym, Musical Instrument Digital Interface
Motion Picture, Sequence, Photograph
Motion Pictures, History, Development
Music, Movement, Sound
Musical Instruments, Tool, Scope
Noise, Physic, Signal
Oboe, Wind, Instrument
Organ, Instrument, Air
Petroleum, Oil, Bituminou
Phonograph, Known, Player
Physic, Science, Constituent
Prince William Sound, Inlet, Gulf
Propeller, Device, Force
Puget Sound, Arm, Pacific Ocean
Radiometer, Instrument, Intensity
Reflection, Physic, Phenomenon
Singing, Use, Voice
Sonar, Acronym, Sound Navigation And Ranging
Sound, Phenomenon, Sense
Determination, Depth, Body
Sound Recording, Reproduction, Conversion
Supersonics, Branch, Physic
Synthesizer, Computer, Peripheral
Tone, Music, Sound
Transformer, Device, Coil

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Tyndall, John, Physicist
Ultrasonics, Branch, Physic
Ventriloquism, Art, Sound
Violin, Instrument, Member
Viscount Melville Sound, Arm, Arctic Ocean
Voiceprint Identification, Method, Person
Warner Brothers, Motion, Picture
Xylophone, Greek, Xylon
Cluster 2, has 8 hits: 'sound:6, long:3, letter:3, sign:2, atlantic ocean:2, mi:
Animal Behavior The, Behavior, Animal
C, English, Romance-language
Diacritic Mark, Sign, Mark
Island Sound, Body, Salt

```
  Letter, Vowel, Engli:
  Pamlico Sound, Inlet, Atlantic Ocean
  Rhyme, Likeness, Sound
  W, Letter, English
Cluster 3, has 19 hits: 'language:14, english:9, speech:6, sound:6, word:5, spok
  American English, English, Spoken
  Celtic Languages, Indo-european, Family
  Chinese Language, Language, Chinese
  Cuneiform, Latin, Cuneu
  Deafness, Inability, Definition
  English Language, Medium, Communication
  English Literature, Literature, England
  Etymology, Branch, Linguistics
  Grammar, Branch, Linguistics
  Greek Language, Language, People
  Hieroglyph, Character, System
  Japanese Language, Language, Spoken
  Language, Communication, Being
  Linguistics, Study, Language
  Phonetics, Branch, Linguistics
  Poetry, Form, Expression
  Semantics, Greek, Semantiko
  Versification, Art, Verse
  Writing, Method, Intercommunication
Cluster 4, has 11 hits: 'sound:11, alphabet:9, letter:9, hieroglyph:8, english:7
  Vowel, English, Alphabet
  Alphabet, Alpha, Beta
  F, Letter, Consonant
  K, Letter, English
  L, Letter, English
  M, Letter, English
  Q, Letter, English
  R, Letter, English
  U, 21st, Letter
  X, Letter, English
  Y, Letter, English


Clustering file strike.txt
Non-empty clusters: 4
Clusters: 4
#   Hits Vals Seed, Value:Count
--- ---- ---- -----------------




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  0    6    0 (OTHER), electron:2, beam:2, tube:2, television:2
  1   11    0 Gary, City, Lake County, strike:10, united states:3, president:2,
  2   10    0 National Labor Relations Act, Nlra, Law, labor:9, strike:8, union:
  3   15    0 Poland, Republic, Polska Rzeczpospolita, government:11, 1980s:8, w
Passes: 453, best pass: 208, best score: 0.445, worst score: 0.154
Cluster 0, has 6 hits: '(OTHER), electron:2, beam:2, tube:2, television:2'
  Baseball, Game, Skill
```

```
  Cathode-ray Tube, Electron, Tube
  Napoleon I, Emperor, French
  Russia, History, Empire
  Television, Tv, Transmission
  Warfare, Use, Force
Cluster 1, has 11 hits: 'strike:10, united states:3, president:2, injunction:2,
  Chartism, Reform, Movement
  Coolidge, John, Calvin
  Defense Systems, Defense, Country
  Deb, Eugene Victor, American Socialist
  Dollfuss, Engelbert, Chancellor
  Fault, Geology, Line
  Gary, City, Lake County
  Homestead Strike, Labor, Strike
  Pullman Strike, See, Deb
  Sound, Phenomenon, Sense
  Ueberroth, Peter Victor, Sport
Cluster 2, has 10 hits: 'labor:9, strike:8, union:7, labor-management relations
  Cleveland, Grover, 22d
  Industrial Workers, World, Former
  International Ladies, Garment Workers, Union
  Knight, Labor, Union
  Labor Relations, Transaction, Determination
  Lockout, Labor, Relation
  National Labor Relations Act, Nlra, Law
  Labor, Relation, Practice
  Strike, Labor, Relation
  Trade Unions, United States, Labor
Cluster 3, has 15 hits: 'government:11, 1980s:8, war:6, country:4, soviet:3, par
  Colombia, Republic, South America
  France, French Rpublique Franaise, Republic
  Ghana, Country, Africa
  Britain, United Kingdom, Great Britain
  Illinoi, East North Central, U.S.
  Italian Italia, Republic, Europe
  Japan, Japanese Dai, Great
  Northern Ireland, Part, United Kingdom
  Poland, Republic, Polska Rzeczpospolita
  Russian Revolution, Event, Russia
  Spain, Spanish Espaa, Monarchy
  Sweden, Konungariket Sverige, Kingdom
  Union, Soviet Socialist Republics, Russian Soyuz Sovyetskikh Sotsialisticheski
  United States, America, Republic
  World War Ii, Military, Conflict


Clustering file utah.txt
Non-empty clusters: 5
Clusters: 5



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#   Hits Vals Seed, Value:Count
```

```
--- ---- ---- --------- - ---
  0    2    0 (OTHER), state:2
  1    3    0 Utah, University, Institution, utah:3
  2    9    0 City, Davis County, Utah, city:8, utah:8, mormon:5, state:4, name:
  3    3    0 Mormonism, World, Religion, mormonism:3, polygamy:3, smith:3, morm
  4    7    0 Green, River, Utah, utah:6, colorado:5, mi:4, km:4, river:2, yampa
Passes: 764, best pass: 515, best score: 0.652, worst score: 0.147
Cluster 0, has 2 hits: '(OTHER), state:2'
  United States, America, Republic
  State, U.S., North
Cluster 1, has 3 hits: 'utah:3'
  Bushnell, Nolan Kay, Founder-chairman
  Orem, City, Utah County
  Utah, University, Institution
Cluster 2, has 9 hits: 'city:8, utah:8, mormon:5, state:4, name:3, lake:3, salt
  City, Davis County, Utah
  Deseret, State, Name
  Logan, City, Seat
  Murray, City, Salt Lake County
  Nevada, State, U.S.
  Provo, City, Seat
  Salt Lake City, City, Capital
  Utah, State, U.S.
  Utah Lake, Freshwater, Lake
Cluster 3, has 3 hits: 'mormonism:3, polygamy:3, smith:3, mormon:3, church:2, ki
  Mormonism, World, Religion
  Smith, Joseph, Religious
  Brigham, Religious, Leader
Cluster 4, has 7 hits: 'utah:6, colorado:5, mi:4, km:4, river:2, yampa:2, ute:2,
  Colorado, State, United States
  Colorado, River, North America
  Salt Lake, Body, Salt
  Green, River, Utah
  Hovenweep National Monument, Colorado, Utah
  Uinta Mountains, Range, Mountain
  Ute, North American Indian, Tribe
```

CLAIMS

I claim:

1. A system for case-based organizing and querying of a database, said database having a set of objects, said system comprising

means for organizing said database, by examining each object in said database and associating that object with a first set of property values;

means responsive to a query, by associating said query with a second set of property values and performing matching on the objects of the database for objects which are similar.

2. A system as in claim 1, wherein said objects comprise text.

3. A system as in claim 1, wherein said first set of property values comprise keywords or other indicators of content.

4. A system as in claim 1, wherein said first set of property values comprise those words which appear more frequently in the document than in the database at large.

5. A system as in claim 1, wherein said first set of property values comprise those words which appear in a predetermined section of text of the object.

6. A system as in claim 1, wherein said first set of property values comprise those words which appear in a title of the object.

7. A system as in claim 1, wherein said matching is case-based matching or other fuzzy associative matching.

8. A system as in claim 1, wherein said query comprises text.

9. A system as in claim 1, wherein said means responsive to a query associates said query with keywords or other indicators of its content.

10. A system as in claim 1, comprising means for presenting a set of matched objects in response to said query.

11. A system as in claim 1, comprising means responsive to refinement of said query.

12. A system as in claim 1, comprising means responsive to iterative refinement of said query.

13. A system as in claim 12, wherein said means responsive to iterative refinement uses a case-based technique.

14. A system as in claim 1, comprising means for ordering said set of matched objects in response to quality of match.

15. A system as in claim 1, comprising means for organizing said set of matched objects.

16. A system as in claim 15, wherein said means for organizing comprises means for grouping said set of matched objects into a set of clusters.

17. A system as in claim 15, wherein said means for organizing comprises means for grouping said set of matched objects into a set of clusters of objects which have similar properties, which relate to similar content, which have similar likelihood to be of relevance to the query, or which have similar likelihood to be of interest to an operator posing the query.

18. A system as in claim 15, comprising means for generating suggestions for iterative refinement of said query.

19. A system as in claim 18, wherein said means for generating is responsive to a result of organizing matched objects.

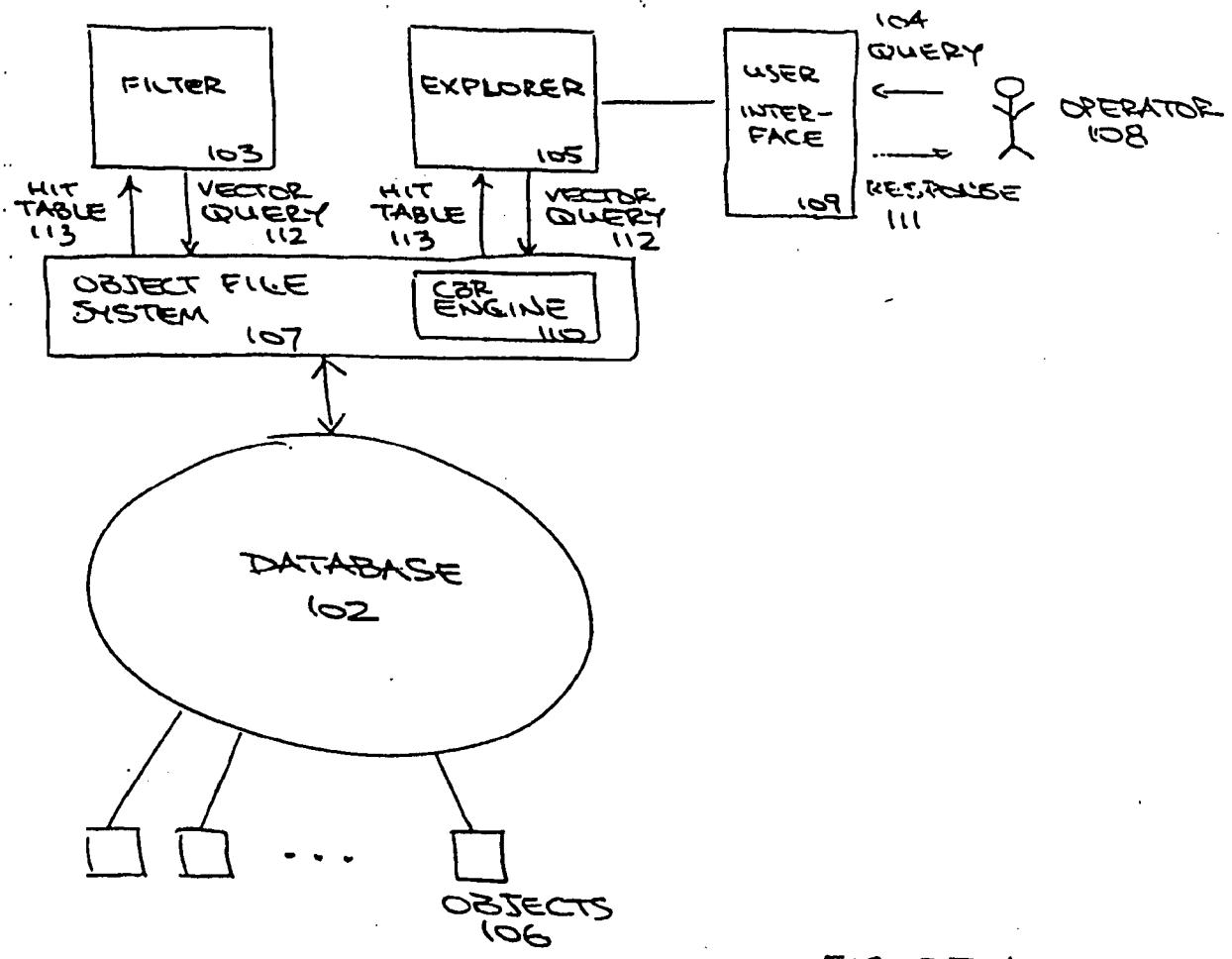

FILTER
103
EXPLORER
105
USER INTER-FACE
109
104
QUERY
OPERATOR
108
RESPONSE
111
HIT TABLE
113
VECTOR QUERY
112
HIT TABLE
113
VECTOR QUERY
112
OBJECT FILE SYSTEM
107
CBR ENGINE
110
DATABASE
102
OBJECTS
106

FIGURE 1.

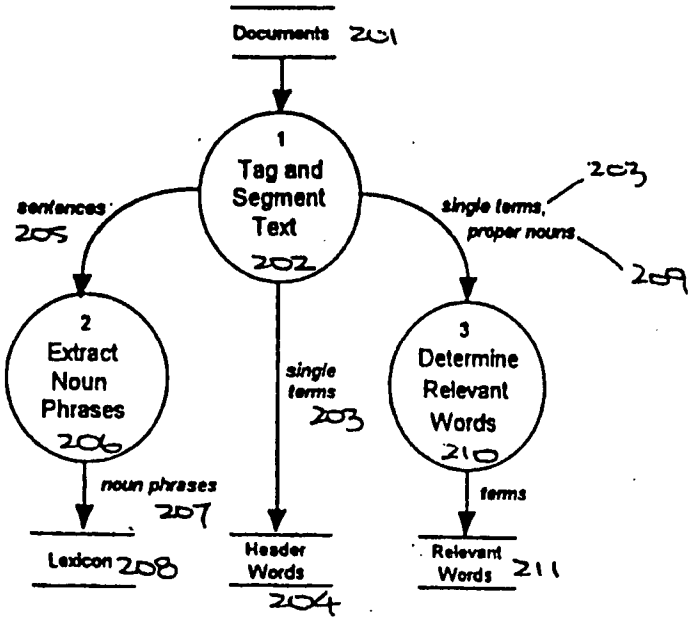

Documents 201
1
Tag and Segment Text
202
sentences 205
single terms, proper nouns 209
203
2
Extract Noun Phrases
206
single terms 203
3
Determine Relevant Words
210
noun phrases 207
terms
Lexicon 208
Header Words 204
Relevant Words 211

FIGURE 2.

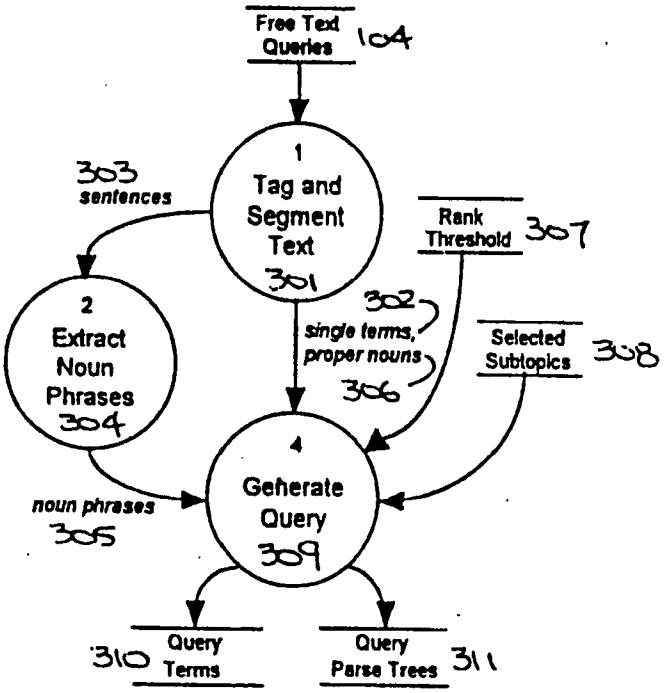

Free Text Queries
104
1
Tag and Segment Text
301
303
sentences
Rank Threshold
307
2
Extract Noun Phrases
304
302
single terms, proper nouns
306
Selected Subtopics
308
4
Generate Query
309
noun phrases
305
Query Terms
310
Query Parse Trees
311

FIGURE 3.

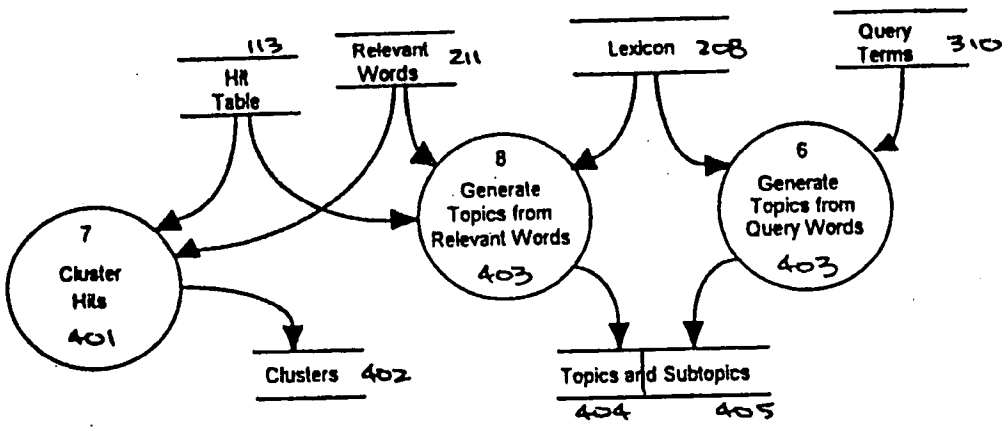

113
Hit Table
Relevant Words 211
Lexicon 208
Query Terms 310
7
Cluster Hits
401
8
Generate Topics from Relevant Words
403
6
Generate Topics from Query Words
403
Clusters 402
Topics and Subtopics
404
405

FIGURE 4.

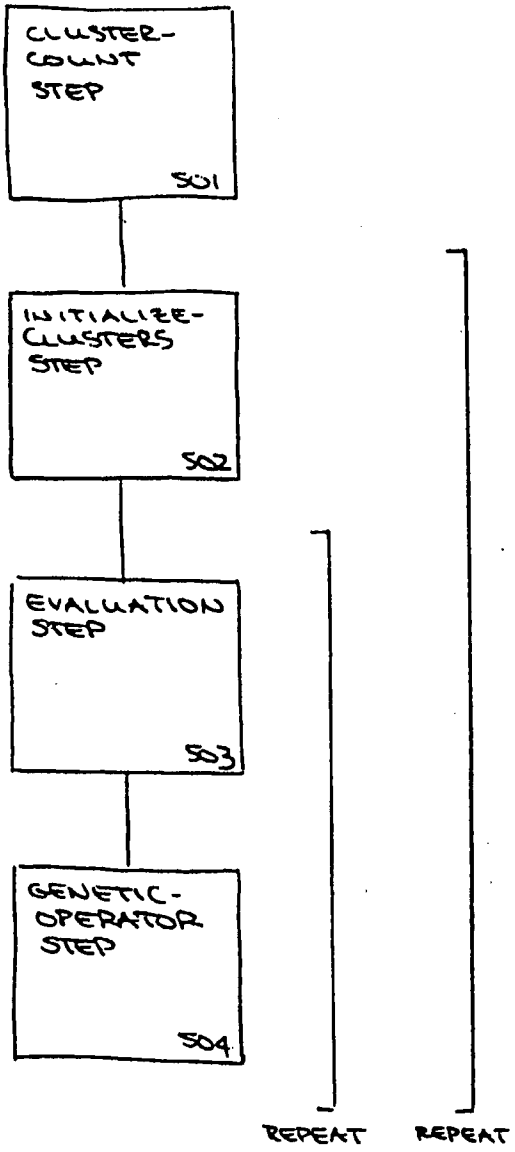

CLUSTER-COUNT STEP
501
INITIALIZE-CLUSTERS STEP
502
EVALUATION STEP
503
GENETIC-OPERATOR STEP
504
REPEAT
REPEAT

FIGURE 5.

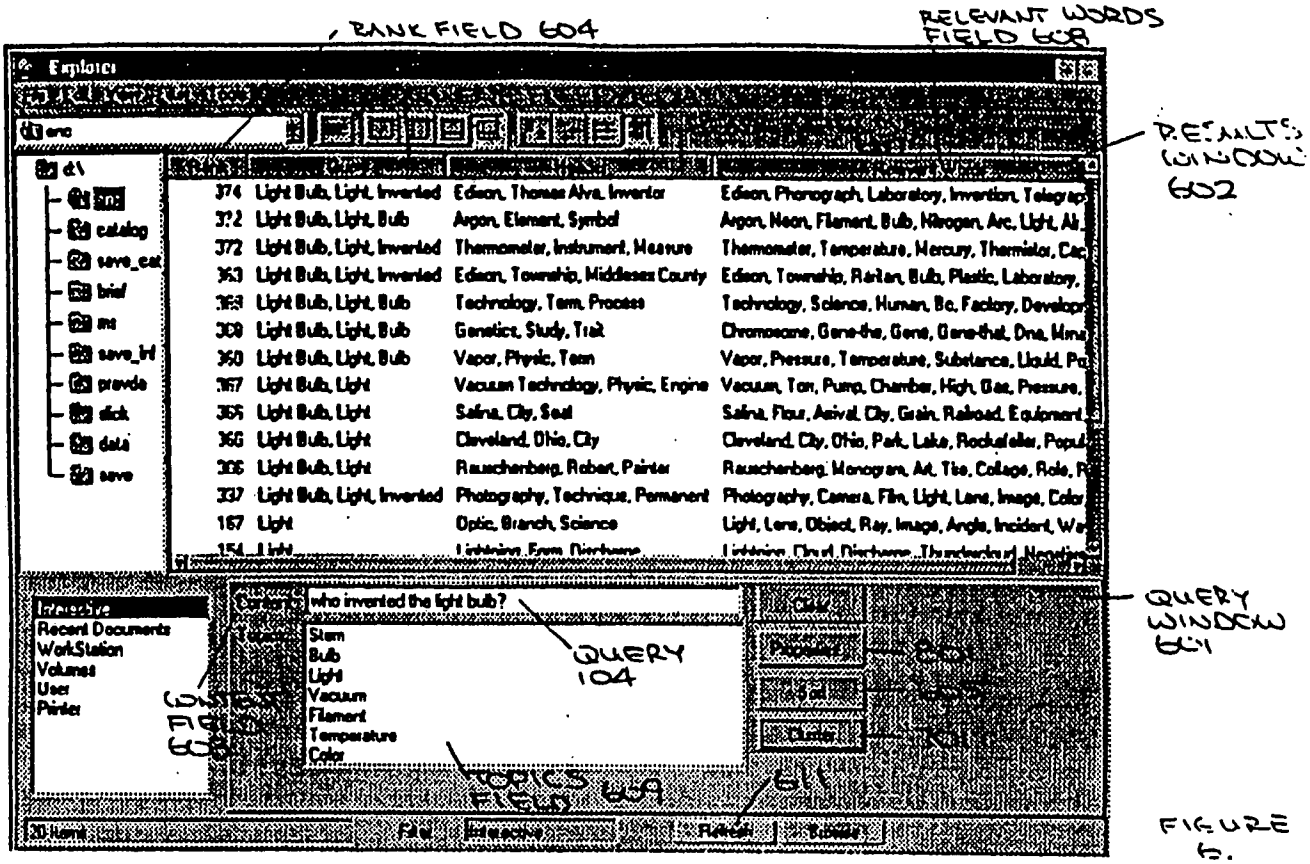
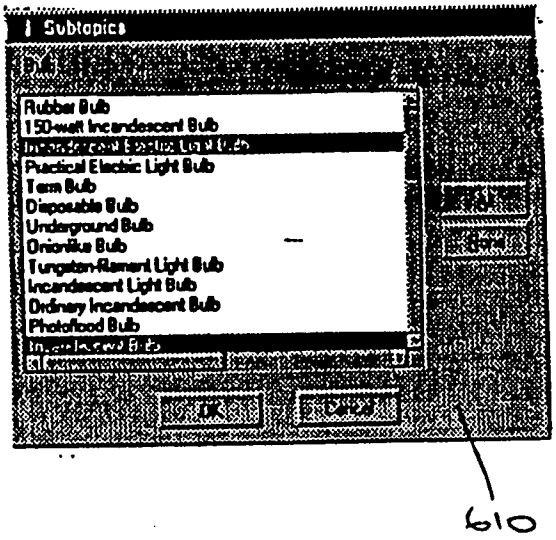
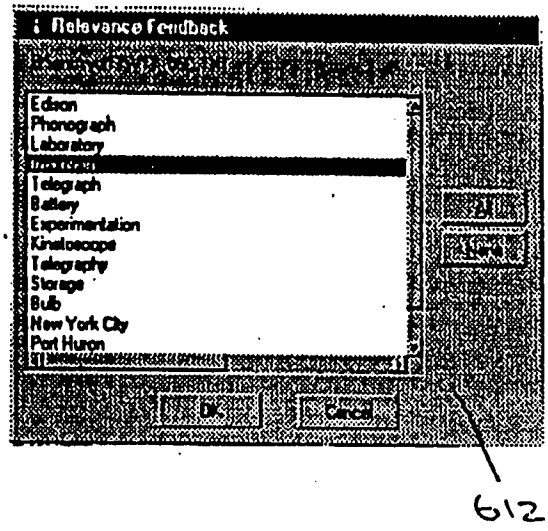

RANK FIELD 604
RELEVANT WORDS FIELD 608
RESULTS WINDOW 602
QUERY WINDOW 601
QUERY 104
TOPICS FIELD 609
611
Explorer
who invented the light bulb?
Stem
Bulb
Light
Vacuum
Filament
Temperature
Color
Interactive
Recent Documents
WorkStation
Volumes
User
Printer
Clear
Process
Cancel
Cluster
Fetch
Tutorial
20 Items
File
Interactive
Fetch
Tutorial

FIGURE 5.


Subtopics
Rubber Bulb
150-watt Incandescent Bulb
Practical Electric Light Bulb
Term Bulb
Disposable Bulb
Underground Bulb
Oriorilke Bulb
Tungsten-Filament Light Bulb
Incandescent Light Bulb
Ordinary Incandescent Bulb
Photoflood Bulb
OK
Cancel
610


Relevance Feedback
Edison
Phonograph
Laboratory
Telegraph
Battery
Experimentation
Kinetoscope
Telegraphy
Storage
Bulb
New York City
Port Huron
OK
Cancel
612

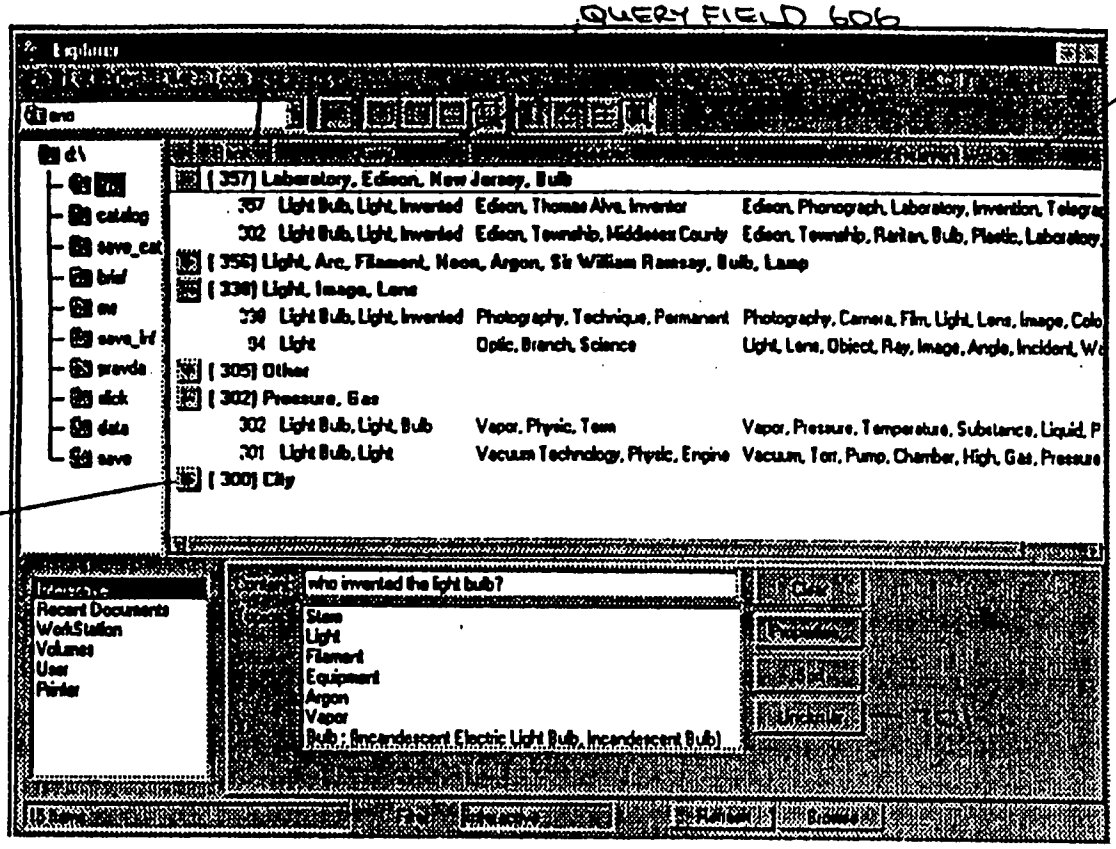

QUERY FIELD 606
RELEVANT WORDS FIELD 608
-PAND -ELD
Explorer
d:\
[357] Laboratory, Edison, New Jersey, Bulb
Light Bulb, Light, Invented Edison, Thomas Alva, Inventor Edison, Phonograph, Laboratory, Invention, Telegra
Light Bulb, Light, Invented Edison, Township, Middlesex County Edison, Township, Raritan, Bulb, Plastic, Laboratory
[356] Light, Arc, Filament, Neon, Argon, Sir William Ramsay, Bulb, Lamp
[338] Light, Image, Lens
Light Bulb, Light, Invented Photography, Technique, Permanent Photography, Camera, Film, Light, Lens, Image, Colo
Light Optic, Branch, Science Light, Lens, Object, Ray, Image, Angle, Incident, W
[305] Other
[302] Pressure, Gas
Light Bulb, Light, Bulb Vapor, Physic, Term Vapor, Pressure, Temperature, Substance, Liquid, P
Light Bulb, Light Vacuum Technology, Physic, Engine Vacuum, Torr, Pump, Chamber, High, Gas, Pressure
[300] City
Recent Documents
WorkStation
Volumes
User
Printer
who invented the light bulb?
Stem
Light
Filament
Equipment
Argon
Vapor
Bulb ; Incandescent Electric Light Bulb, Incandescent Bulb)

FIGURE 7.

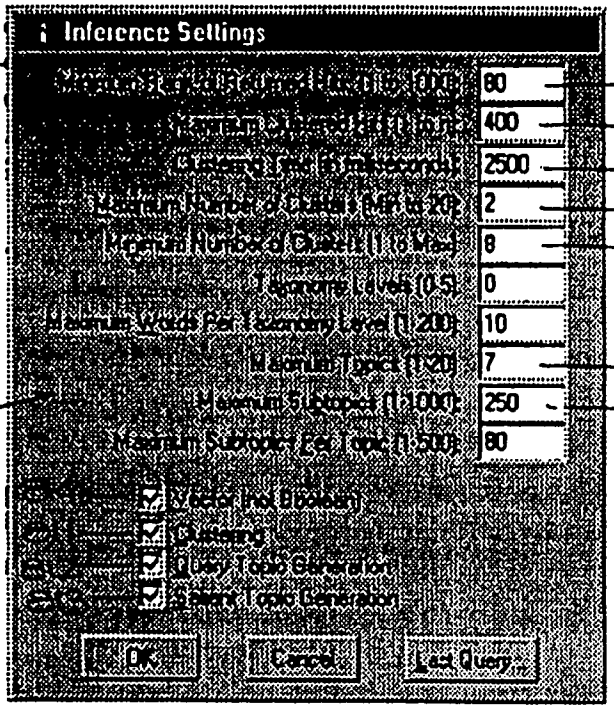

PROPERTIES WINDOW
802
Inference Settings
80
400
2500
2
8
0
10
7
250
80
803
804
805
806
807
808
809
810
OK
Cancel
Last Query...

FIGURE 8.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/07569

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G06F 15/40
US CL :395/600; 364/419.19

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 395/600; 364/419.19

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: information retrieval, document retrieval, case-based reasoning, cluster, keyword, index, text, full-text

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X - Y	US, A, 5,099,426 (Carlgren et al.) 24 March 1992, col. 4, lines 4-68, col. 5, lines 1-11.	1-4, 7-13 --------- 5-6, 14-19
Y, P	US, A, 5,303,361 (Colwell et al.), 12 April 1994, col. 2, lines 12-35.	14
Y	US, A, 5,062,074 (Kleinberger et al.) 29 October 1991, col. 9, lines 58-68, col. 10, lines 1-68.	15-19
X	US, A, 5,201,048 (Coulter et al.) 06 April 1993, abstract, col. 2, lines 25-68, col. 3, lines 1-48.	1-3

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
29 AUGUST 1994

Date of mailing of the international search report
24 OCT 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Authorized officer
B Harden
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